REVIEW RESOURCES

Introduction

This section provides summaries of the information presented in each lesson. You may use these lesson summaries to guide you through the computer-based lessons or to help you prepare for the on-line tests.

These materials can be reviewed on-line if you need a quick refresher. However, if you intend to study these materials, you should print them using the Print function in your Internet browser. (The Print function can be found at the top of each screen.) Click on a lesson title to access the resource materials.

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Lesson 1: Defense Acquisition Workforce Improvement Act (DAWIA)

Why DAWIA?

Since the "birth" of formal acquisition in the 1940's, the need for highly qualified acquisition personnel has been recognized. As time passed, there was an increasing demand for acquisition personnel to have more sophisticated competencies.

Today's acquisition professional must possess increasing levels of:

- Specialized knowledge.
- Analytical skills.
- Good judgment.

In 1990, Congress passed the Defense Acquisition Workforce Improvement Act. The Act's intent is to ensure that DOD has qualified personnel to manage the acquisition of defense systems. Skilled personnel are needed to meet the challenges associated with defense systems that have become increasingly complex and costly.

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What is DAWIA?

The Act establishes requirements for both defense acquisition positions and defense acquisition workforce members. The Act requires that DOD designate specific jobs as "Acquisition" positions and provide a structured approach for filling these designated positions with qualified acquisition personnel. Ensuring qualified personnel requires that DOD establish standards for education, training, and experience.

The Act requires that DOD provide training to:

- Permanent-status civilian and military personnel who occupy designated acquisition positions.
- Personnel in acquisition career development programs.

Personnel in the above two categories are called the "Acquisition Workforce."

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Who are the Key Players?

Several organizations work together to implement DAWIA. These organizations include:

- Defense Acquisition University (DAU)
- Functional Boards
- Directors of Acquisition Career Management (DACMs)
- Consortium Schools

Defense Acquisition University

DAWIA directed DOD to establish the Defense Acquisition University (DAU). DAU coordinates the DOD acquisition and training program to meet the training requirements of personnel serving in acquisition positions.

Through its consortium members, DAU sponsors acquisition training to support the career goals and professional development of the acquisition workforce. DAU also supports acquisition management research, publications, and symposia.

Functional Boards

Functional Boards are comprised of experienced practitioners. These Boards advise the Under Secretary of Defense (Acquisition and Technology) on:

- Issues related to acquisition workforce career development.
- Mandatory training, education, and experience for each functional area.

DAU works with these Boards to identify performance outcomes that are incorporated in the various courses. By establishing performance outcomes, Boards help ensure that course content is current and relevant.

Directors of Acquisition Career Management (DACMs)

The Director of Acquisition Career Management (DACM) for each DOD Service or Agency:

- Monitors training requirements and DAWIA compliance.
- Assigns students to required courses offered by DAU consortium schools.
- Projects the numbers of individuals requiring training each year.
- Certifies individuals as having met DAWIA standards.

Consortium Schools

Consortium schools work with DAU to:

- Develop and deliver courses to meet the requirements established by the Functional Boards.
- Offer courses to meet the projected training needs established by the DACMs.
- Conduct research and publish information about acquisition management.

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Local Resources

In your own organization there are people who will work with you to ensure that you receive DAWIA-required training. To obtain DAWIA training follow the trail listed below:

- Local Training Manager
- Organization Acquisition Career Manager
- Service or Agency Acquisition Training Manager
- Service or Agency DACM

The Local Training Manager is your best source of training information.

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Acquisition Positions

DAWIA mandates that DOD designate specific positions as acquisition positions. These positions:

- Include both civilian and military billets.
- Generally are located in organizations that have acquisition missions.
- May be located in other headquarters or support organizations.

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Defense Acquisition Career Fields

The designated acquisition positions are grouped into 11 acquisition career fields:

- Program Management
- Communications/Computer Systems
- Contracting (Including Construction)
- Purchasing and Procurement Technician
- Industrial/Contract Property Management
- Systems Planning, Research, Development, and Engineering
- Test and Evaluation
- Manufacturing, Production, and Quality Assurance
- Acquisition Logistics
- Business, Cost Estimating, and Financial Management
- Auditing
- Additional Acquisition Positions

Program Management

The program management career field includes, but is not limited to:

- Program Manager (PM)
- Deputy Program Manager (DPM)
- Program Executive Officer (PEO)
- Deputy Program Executive Officer positions

Other examples include staff positions such as program analyst or program integrator.

Responsibilities may be broad or focused and may be line or staff in nature. Defense acquisition programs are managed in accordance with DODD 5000.1 and DOD 5000.2-R.

Communications/Computer Systems

This field includes:

- Computer Systems Analysts
- Information Management Specialists
- Telecommunications Managers
- Software/Automation Specialists
- Computer Engineers

These positions directly support the acquisition of automated information systems and interconnecting components (to include hardware, software, and firmware products) used to create, record, produce, store, retrieve, process, transmit, disseminate, present, or display data or information. This includes computers, ancillary equipment, software, telecommunications, and other

related services.

The employee:

- Identifies requirements.
- Writes and/or reviews specifications.
- Identifies costs.
- Obtains resources (manpower, funding, and training).
- Tests and evaluates.
- Plans, obtains, and manages life-cycle support (operations, maintenance, and replacement).

Contracting (Including Construction)

The contracting career field includes the positions of:

- Contract Negotiator
- Contract Specialist
- Contract Termination Specialist
- Contract Administrator
- Procurement Analyst
- Administrative Contracting Officer
- Procuring Contracting Officer
- Contract Price and/or Cost Analyst
- Contracting Officer
- Termination Contracting Officer

Individuals in this career field develop, manage, supervise, or perform procedures involving:

- Procurement of supplies and services
- Construction, research, and development
- Acquisition planning
- Cost and price analysis
- Selection and solicitation of sources
- Preparation, negotiation, and award of contracts
- All phases of contract administration
- Termination or closeout of contracts

The employee is required to have knowledge of:

- Legislation, policies, regulations, and methods used in contracting
- Business and industry practices
- Sources of supply
- Cost factors
- Cost and price analysis techniques
- General requirements characteristics

Purchasing and Procurement Technician

Individuals in the purchasing and procurement technician career field are typically purchasing agents or supervisory purchasing agents.

This function requires the individual to purchase, rent, or lease supplies, services, and equipment through either formal open-market methods or formal competitive bid procedures, with the primary objective of the work being the rapid delivery of goods and services in direct support of operational requirements.

It requires knowledge of commercial supply sources and of common business practices for roles, prices, discounts, deliveries, stocks, and shipments.

Industrial/Contract Property Management

The industrial/contract property management career field includes:

- Industrial Property Management Specialist
- Property Administrator
- Industrial Plant Clearance Specialist
- Plant Clearance Officer
- Contract and Industrial Specialist (if assigned property management responsibilities)

Individuals in this career field include personnel who perform, manage, supervise, or develop policies and procedures for Government property. It may involve the acquisition, control, management, use, and disposition of Government-owned property used by contractors or storage to support future contractual requirements.

Responsibilities include:

- Providing guidance, counsel, and direction to Government and contractor managers and technicians relating to regulatory and contractual requirements for managing Government property.
- Participating in pre-award surveys and post-award reviews.
- Reviewing contracts assigned for property administration.
- Evaluating a contractor's property management system and approving the system or recommending disapproval.
- Developing and applying property systems analysis programs to assess the effectiveness of contractors' Government property management systems.

Systems Planning, Research, Development, and Engineering

Personnel in this field are usually engineers and scientists with degrees in performing systems planning, research and development, and/or other engineering tasks. These individuals may include managers or technical specialists in:

- Engineering
- Chemistry
- Physics
- Operations Research
- Mathematics
- Computer Science Fields

These positions require the incumbent to plan, organize, monitor, oversee, and/or perform engineering activities that relate to the design, development, fabrication, installation, modification, or analysis of systems or system components. Duties may require identification, establishment, organization, or implementation of acquisition engineering objectives and policies, or establishment of specifications.

Test and Evaluation

Individuals who work in this field are usually engineers, scientists, operations researchers, computer scientists, and other degree-holding technical personnel who perform test and evaluation tasks in support of acquisition.

This field includes managers and technical specialists in engineering, physics, operations research, mathematics, and computer science fields who are responsible for planning, monitoring, conducting, and evaluating tests of prototype, new, or modified weapon systems equipment or materiel. Individuals also:

- Analyze, assess, and evaluate test data and results
- Prepare assessments of test data and results
- Write reports of findings

Manufacturing, Production, and Quality Assurance

Acquisition-related manufacturing and production personnel, and production career field duties, vary greatly in managerial, administrative, and technical content. Acquisition-related contractor, manufacturing, and production duties usually involve program management or monitoring the manufacturing and production efforts of private-sector contractors.

The quality assurance specialist:

- Manages quality assurance activities to establish essential quality standards and controls, and develops and executes plans that focus on quality of design, quality of conformance, and fitness for use.
- Integrates quality plans into the system engineering process.
- Develops policies, procedures, test provisions, and quality requirements in specifications, standards, and solicitations.
- Evaluates quality assurance during acquisition such as design reviews, functional and configuration audits, production readiness reviews, and milestone reviews.

Acquisition Logistics

The acquisition logistics career field includes individuals who are involved in Support activities as defined in DOD Directive 5000.1 and DOD Regulation 5000.2-R. They manage logistics activities associated with the procurement, integration, and fielding of support systems/environment, weapons systems/equipment, or system modifications.

Business, Cost Estimating, and Financial Management

This career field includes individuals responsible for:

- Financial planning
- The formulation of financial programs
- The administration of budgets

They are also responsible for the expenditure, obligations, and accountability of funds, cost and schedule performance management of contractors, and cost estimating.

Additional duties include advising or assisting commanders, program managers, and other officials in discharging all aspects of their responsibilities for business management in direct support of the defense acquisition process.

Auditing

The mandatory education, experience, and training requirements for the auditing career field apply to contract auditors. Persons in this career field perform contract auditing, accounting, and financial advisory services to DOD and other Government agencies in negotiations, administration, and settlement of contracts and subcontracts.

Duties include:

- Evaluating information about contractor economic assertions.
- Comparing those assertions to established criteria.
- Reporting the results to interested third parties.

Audits are made on:

- Proposal submissions
- Incurred cost
- Compliance with the "Truth in Negotiations Act"
- Compliance with cost accounting standards
- Contract terminations
- Claims for abnormal conditions
- Contractor financial condition
- Contractor systems and operations

Additional Acquisition Positions

There are two additional acquisition positions that are covered by DAWIA, but are not career fields:

- Education, Training and Career Development (for example, DAU personnel)
- Program Management Oversight (for example, Acquisition Workforce members assigned to the Inspector General)

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Career Field Levels

Each career field is divided into three career levels for the purposes of establishing standards and qualifications:

- Level I—Basic or Entry Level
- Level II—Intermediate or Journeyman Level
- Level III—Advanced or Senior Level

Acquisition Career Level I—Basic or Entry Level

The purposes of this career level are to:

- Establish fundamental qualifications and expertise within a job series or career field.
- Provide exposure to acquisition functions and the roles of various specialties within acquisition management.

Typical grade levels:

- GS-5 to GS-9
- Officer 0-1 to 0-3
- Enlisted based on Service policy

Acquisition Career Level II—Intermediate or Journeyman Level

The purposes of this career level are to:

- Develop specialized knowledge and skills within a career field.
- Broaden background information while gaining more general expertise in the overall processes in his or her career field.

Typical grade levels:

- GS-9 to GS-12
- Officer 0-3/0-4
- Enlisted based on Service policy

Acquisition Career Level III—Advanced or Senior Level

The purposes of this career level are to:

- Develop depth expertise within a career field or functional area.
- Expand the breadth of knowledge across the entire acquisition process.

Typical grade levels:

- GS-13 and above
- Officer 0-4 and above

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Acquisition Corps

The Acquisition Corps are members of the Acquisition Workforce who are:

- Senior civilian and military personnel.
- Able to meet established qualifications.
- Eligible to fill Critical Acquisition Positions.

Exception: In the Department of the Navy, the Acquisition Corps is designated as the "Acquisition Professional Community."

Acquisition Corps: Qualifications

Members of the Acquisition Corps must meet rigorous qualifications. In addition to being a GS-13/0-4 or higher (Army GS-14/0-5), Acquisition Corps members must have:

- Education: Baccalaureate Degree and 24 credit hours in selected disciplines or 24 credit hours in your career field and 12 credit hours in selected disciplines.
- Experience: Four years in an ACQ position
- Training: Level II Certification

Civilian members must sign a mobility agreement.

Disciplines

Acquisition Corps Semester Credit Hours are required in these selected disciplines:

- Accounting
- Business Finance
- Law
- Contracts
- Purchasing
- Economics
- Industrial Management
- Marketing
- Quantitative Methods

- Organization and Management

Critical Acquisition Positions

Critical Acquisition Positions:

- Are key positions in the DOD acquisition system.
- Are designated by the Secretary of Defense.
- May only be filled by an Acquisition Corps member.

Examples of Critical Positions are:

- Program Executive Officers (PEOs)
- Deputy PEOs
- Program Managers (PMs)
- Deputy PMs
- Senior Contracting Officers

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DAWIA Certification

To become certified in any career field, you must complete the mandatory experience, education, and training standards for each level. Acquisition Workforce members are encouraged to become certified in more than one career field.

Acquisition Career Development Program

DAWIA certification is part of the overall DOD Acquisition Career Development Program. The goals of this program are to:

- Develop, on a long-term basis, a highly qualified Acquisition Workforce.
- Meet current and future needs for acquisition personnel.
- Increase proficiency of DOD acquisition personnel in their present positions.
- Ensure efficient use of training and education resources.

The Acquisition Career Development Program Manual (DOD 5000.52-M) establishes the DOD Acquisition Career Development Program and includes the following information:

- Experience, education, and training standards for specific acquisition positions and career fields.
- Certification guidelines for each career path and level.
- Waiver process and alternative ways to satisfy requirements.

You should be familiar with the requirements for being certified in your selected career fields. The starting point is to review the requirements established in DOD 5000.52-M. A copy of DOD 5000.52-M can be found on the Defense Acquisition Deskbook.

Certification Process

Certification is the process through which DOD determines that an individual meets the mandatory standards (education, training, and experience) established for each career level.

You should check with your DACM for specific information about the certification process used in your organization. You are responsible for submitting certification requests through your local Training Manager or Organizational Acquisition Career Manager.

Certification Timelines

Once individuals enter Level I positions, their organizations have 18 months in which to qualify them to meet these standards.

Prior to entering Level II or III positions, individuals should have met mandatory standards at those levels. In some cases, individuals may be allowed up to 18 months to meet Level II or III certification requirements.

Certification Exceptions

There may be alternative methods for satisfying some certification requirements.

- Experience: An acquisition-related academic program may serve as a substitute for some required experience.
- Education: Experience within selected career fields, and testing in others, may satisfy some educational requirements.

Speak with your Training Manager, Acquisition Workforce Manager, or DACM for additional information.

Certification Records

Each military service and the DOD agencies maintain databases to track certification levels of all Acquisition Workforce members. The information in this database is used during screening and selection of candidates for Acquisition Positions. The accuracy of this information is critical to your career advancement.

You are responsible for making sure your records are accurate by:

- Submitting records of your achievements to your Training Manager.
- Verifying that the achievement was properly recorded.

Individual Development Plans and Career Development Plans

Individual Development Plans (IDPs) for civilians and Career Development Plans for military lay out an individual's education, training, and experience needed for career development. They document the training and developmental activities you need for DAWIA certification.

IDPs are mandatory for each civilian member of the Acquisition Workforce until Level III certification is achieved.

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Lesson 2: Systems Acquisition Management: An Introduction

Program Management Offices

Program Management Offices (PMOs) manage the acquisition of defense systems that support the warfighters. Many members of the acquisition workforce are connected, whether directly or indirectly, to a PMO.

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Acquisition Program Management

Acquisition Program Management in DOD is very similar to management in the private sector. There is great pressure today on the DOD and the entire Federal Government to conduct its acquisition business more like the private sector by using more effective planning, staffing, organizing, controlling, and leading. In addition to following sound business management practices, DOD managers must:

- Ensure that public funds are being used prudently.
- Accomplish a mission rather than make a profit.
- Promote social welfare considerations (e.g., small and disadvantaged businesses).
- Ensure that all Government regulations (e.g., environmental) are followed.

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Systems Acquisition Management

Systems Acquisition Management within DOD is the process used to acquire quality products. The primary objectives of this process are to:

- Satisfy the needs of operational users.
- Provide measurable improvements in mission capabilities.
- Acquire products in a timely manner at a fair and reasonable cost.

Systems

A system includes all of the elements (e.g., hardware, software, logistics support, personnel) needed to assist DOD in conducting its mission of deterring or winning war.

Acquisition

Acquisition includes:

- Determination of need
- Research, development, test, and evaluation
- Production

- Deployment/Fielding
- Operations and support
- Plan for disposal

These actions provide a logical means of and phases for translating user needs into operationally effective, suitable, and survivable systems.

Management

Management includes the tasks (e.g., planning, budgeting, organizing, staffing, controlling, leading) required to accomplish a specified project.

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What Is Risk?

Think of risk as a way of measuring the potential that an event will result in a negative consequence. By doing so, risk can be seen as being comprised of two variables, probability and consequences. When assessing risk, a Program Manager must consider the probability that an event will occur and the consequences should that event occur.

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Risk Factors

Program Managers must assess and manage risk to ensure that DOD is acquiring optimum systems that meet all requirements. Successful acquisition management is more likely when the following risk factors are assessed and addressed:

- Cost
- Schedule
- Performance

Risk Factor Examples: Cost

Risks that could impact program costs include:

- Increases in material prices.
- Higher-than-anticipated labor rates.
- Other factors that can change current program cost estimates.

Risk Factor Examples: Schedule

Risks that could impact program schedule include:

- Late deliveries.
- Political pressure.
- Changing requirements (user needs the system sooner or user adds requirements).

Risk Factor Examples: Performance

Risks that could impact technical performance include:

- Use of new or exotic materials or processes.
- Use of unproven technology.

- Use of new applications to meet demanding user requirements.

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Handling Risk

After assessing risk, Program Managers determine how best to handle it. Four strategies for handling risk are:

- Controlling risk
- Avoiding risk
- Assuming risk
- Transferring risk

These strategies can be used alone or in combination.

Strategy: Control the Risk

Controlling risk means lowering the chance that the event will occur by:

- Using multiple contractors.
- Conducting multiple tests.
- Using technology and processes proven to control the risk.

Strategy: Avoid the Risk

Avoiding risk means changing the source (element or constraint) that is subjecting the program to risk. Risk may be avoided by:

- Reducing the scope of performance objectives.
- Using more expensive materials or processes with proven track records.
- Extending the schedule to increase the probability of success.

Strategy: Assume the Risk

Assuming risk means planning for the potential consequences by:

- Accepting the risk.
- Putting a monitoring process in place.
- Taking future action (e.g., reserving funds, modifying schedules) if necessary.

All unknown or unidentified risks are assumed.

Strategy: Transfer the Risk

Transferring risk means having someone else take accountability for the risk. Risk can be transferred by:

- Using firm-fixed price contracts and warranties to transfer cost risk to the contractor.
- Assigning responsibility to the organization that is best suited to minimize the probability of a negative consequence.

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Acquisition Authorities

The authority for DOD to conduct systems acquisition flows from the following principal sources:

- The Law
- DOD Acquisition Policy Documents
- Federal Acquisition Regulation

The Law

Statutory authority from Congress provides the legal basis for systems acquisition. Some of the most prominent laws are:

- Armed Services Procurement Act (1947), as amended
- Small Business Act (1963), as amended
- Office of Federal Procurement Policy Act (1983), as amended
- Competition in Contracting Act (1984)
- DOD Procurement Reform Act (1985)
- DOD Reorganization Act of 1986 (Goldwater-Nichols)
- Federal Acquisition Streamlining Act (FASA) of 1994

DOD Acquisition Policy Documents

DOD 5000.2-R

This DOD regulation establishes a simplified and flexible management framework for translating mission needs into stable Major Defense Acquisition Programs (MDAPs) and Major Automated Information Systems (MAISs). This regulation applies specifically to all MDAPs and MAISs and contains mandatory procedures and policies for these programs.

DODD 5000.1

This directive states the policies and principles that guide all defense acquisition programs. In addition, this directive identifies the DOD key acquisition officials and forums.

Federal Acquisition Regulation (FAR)

The FAR is the primary regulation for use by all Federal agencies for the acquisition of supplies and services with appropriated funds. The FAR guides and directs DOD Program Managers in many ways including acquisition planning, competition requirements, contract award procedures, and warranties.

DOD has supplemented the FAR to describe its own procedures. This supplement is called the DFAR.

Environmental Safety and Health Requirements

The Program Manager must ensure compliance with environmental safety and health regulations and laws. The goal of Environmental Safety and Health (ESH) is to eliminate, reduce, and control environmental impacts.

Two categories of environmental laws support the accomplishment of this goal:

- Procedural or "Future" laws
- Substantive or "Past" and "Present" laws

Procedural or "Future" Laws

Procedural or "Future" laws:

- Establish a planning process.
- Impose penalties that may delay programs.
- Assign compliance responsibility to the Program Manager.

Environmental impacts must be considered as an integral part of any acquisition planning effort. The major procedural law affecting DOD systems acquisition management is the National Environmental Policy Act (NEPA).

National Environmental Policy Act (NEPA)

The National Environmental Policy Act:

- Requires DOD to:
  - Evaluate how the development, testing, production, and disposal of a weapon system will affect the environment.
  - Design the system in such a way as to minimize any negative impact, before acquisition of that weapon is approved.
  - Assess all programs, regardless of size, to determine their effect on the environment.
- Gives the public the right to be informed and to challenge actions proposed by DOD that may have environmental impact.

Substantive or "Past" and "Present" Laws

"Past" laws apply to actions that have already happened or are ongoing. These laws deal with:

- Cleaning up the environment.
- Correcting past mistakes.
- Determining who is responsible for paying costs of contaminated sites.

"Present" laws are concerned with actions that are taking place now. These laws deal with controlling environmentally hazardous substances and activities.

Violation of these laws carries the risk of civil or criminal penalties. Actual compliance with many of these laws is up to the contractor. However, DOD officials can be held personally liable for violations of environmental laws.

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What Are Decision Support Systems?

DODD 5000.1 describes the integrated framework that is used for the management of all systems acquisition. This integrated framework is composed of three decision support systems that operate continuously and must interface on a regular basis to enable DOD leadership to make informed decisions regarding the best allocation of scarce resources.

1. Planning, Programming, and Budgeting System
2. Requirements Generation System
3. Acquisition Management System

Planning, Programming, and Budgeting System

The Planning, Programming, and Budgeting System (PPBS) is DOD's primary resource allocation process. The PPBS:

- Is a calendar-driven process used for securing funding for a major acquisition program.
- Offers the basis for informed affordability assessment and resource allocation decisions.
- Provides a formal, systematic structure for making decisions on policy, strategy, and the development of forces and capabilities to accomplish anticipated missions.

Requirements Generation System

The Requirements Generation System (RGS):

- Is driven by warfighting deficiencies or needs.
- Determines mission requirements and strategies for meeting those requirements.
- Provides the basis for establishing priorities.

Acquisition Management System

The Acquisition Management System (AMS):

- Is an event-driven process that emphasizes risk management.
- Involves the process of periodic review and approval of programs to progress into subsequent phases of the acquisition life cycle.
- Provides a streamlined management structure.
- Links milestone decisions to demonstrated accomplishments.

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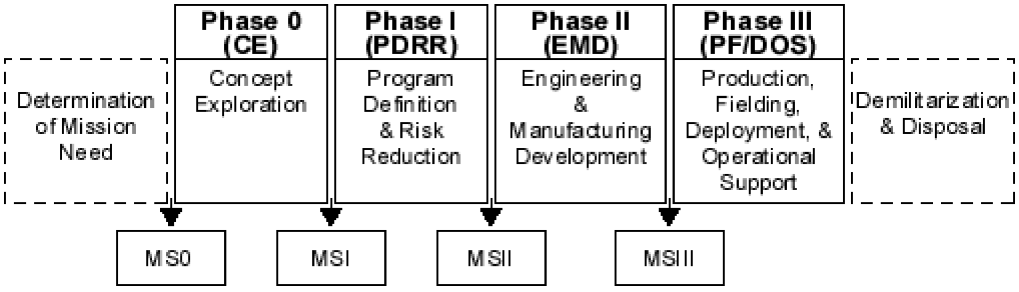
REVIEW RESOURCES

Lesson 3: Systems Acquisition Management: Introduction to the Acquisition Life Cycle

What Is the Acquisition Life Cycle?

The Acquisition Life Cycle consists of sequential phases separated by decision points called Milestones. Each phase contains specific activities based on how much risk is associated with the system to be acquired. Not all phases are required for every program.



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Determination of Mission Need

While not a formal phase of the life cycle, this preliminary activity is called the "Determination of Mission Need." During this period, mission needs or requirements are established by the Services, Defense Agencies, or Commanders in Chief (CINCs) of the Unified Commands. These individuals are commonly referred to as "the users."

Analysis of Non-Materiel Solutions

During the Determination of Mission Need, non-materiel solutions, such as changing tactics or training, are considered before DOD decides to spend money to develop or buy new systems.

Mission Need Statement (MNS)

When non-materiel approaches are not feasible, the user describes the requirement for a materiel solution in a document called a Mission Need Statement. A Mission Need Statement (MNS) is a non-system-specific statement of operational capability need prepared in accordance with CJCSI 3170.01.

Before the MNS is submitted to the acquisition community, the user’s chain of command must first validate and approve the requirement.

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Milestone 0 Review

The acquisition community holds a Milestone 0 Review to formally accept the MNS for study and determine what minimum number of alternatives should be considered. A formal memo, called an Acquisition Decision Memorandum (ADM), is written to document approvals to proceed to the next phase of the acquisition life cycle.

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Concept Exploration—Phase 0

After Milestone 0 Review, the Concept Exploration (CE) Phase begins. During this phase an Analysis of Alternatives (AoA) is conducted. The AoA provides data for selecting the conceptual approach that will satisfy the mission needs in the most cost-effective manner.

During CE, the main activity is conducting studies to analyze the proposed concepts. Contractors and/or Government laboratories help conduct this phase. The Government tries to keep an open mind, looking at all reasonable alternatives industry has to offer.

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Operational Requirements Document

Based on the results of these studies, the user prepares an Operational Requirements Document (ORD). An ORD documents the user's thresholds (minimum acceptable value) and objectives. It also provides system-specific requirements such as range, speed of data transmission, and reliability.

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Milestone I Review

The ORD, study results, and additional information from the Concept Exploration Phase are packaged in one or more documents for the Milestone Decision Authority (MDA). The MDA holds a Milestone I Review to formally consider the request to initiate a new acquisition program. The MDA writes an Acquisition Decision Memorandum documenting approval to proceed to the next life-cycle phase.

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Program Definition and Risk Reduction—Phase I

The focus of the Program Definition and Risk Reduction (PDRR) phase is to demonstrate and validate that the technological capability is achievable within the required timeframe and within available resources. The major activities conducted during this phase include:

- Verifying the preliminary design and engineering approach.
- Designing subsystems.
- Building models and prototypes.
- Testing and evaluating subsystems (referred to as developmental testing and evaluation).
- Analyzing tradeoffs in depth.
- Planning future efforts.

Major Activities of the PDRR Phase

During the PDRR phase:

- Risks (i.e., technical, cost and schedule) associated with the effort are identified and strategies are generated for addressing those risks.
- A request for proposals (RFP) is issued soliciting proposals for implementing the selected concept.
- The contractor(s) with the best-value proposal(s) is/are selected to implement the chosen concept.

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Milestone II Review

MDA holds a Milestone II Review to determine readiness to proceed to Engineering and Manufacturing Development (EMD). The MDA then writes an Acquisition Decision Memorandum approving entry into the next life-cycle phase where a contract is issued for the development of the system.

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Engineering and Manufacturing Development—Phase II

The primary focus of the EMD phase is on finalizing the system design and ensuring that manufacturing processes are ready for full-scale production. During the EMD phase:

- System/equipment and support items are fully developed, engineered, designed, and fabricated.
- Developmental tests and evaluations (DT&E) are conducted to ensure that specifications are met.
- Operational tests and evaluations (OT&E) are conducted to ensure the system is effective and suitable for the users in an operational environment.

During the Engineering and Manufacturing Development phase, conducting a Low Rate Initial Production (LRIP) may be requested. LRIP Quantities are the minimum number of systems (other than ships and satellites) to:

- Provide production representative articles for OT&E.
- Establish the initial production base.
- Permit an orderly increase in production rate sufficient to lead to full-rate production upon successful completion of operational testing.

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Milestone III Review

MDA holds a Milestone III Review to determine if the system is ready for full-rate production. MDA then writes an Acquisition Decision Memorandum approving entry into the next life-cycle phase where the system is manufactured in quantity and sent to the users.

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Production, Fielding/Deployment, and Operational Support—Phase III

The primary focus of the PF/DOS phase is on manufacturing the system in quantity; fielding/deploying the system to the users; and training personnel to operate and maintain the system. Major activities include:

- Operational and support systems are procured and put into place.
- Items are manufactured.
- Operational units are trained.
- Systems are fielded/deployed to the users.

Follow-On Testing and Evaluation

It is critical to continue testing and evaluating the system throughout its life. Continued testing may find that there is a need to modify the system to make it more efficient, effective, or durable. Small modifications and upgrades are accomplished through the following means:

- Engineering Change Proposal (ECP)
  An Engineering Change Proposal goes to the responsible authority recommending that a change to an original item of equipment be considered, and the design of engineering change be incorporated into the article to modify, add to, delete, or supersede original parts.

- Preplanned Product Improvement (P3I)
  Preplanned Product Improvement is planned future evolutionary improvement of developmental systems for which design considerations are effected during development to enhance future application of projected technology. P3I includes improvements planned for ongoing systems that go beyond the current performance envelope to achieve a needed operational capability.

- Service Life Extension Program (SLEP)
  A Service Life Extension Program details modifications to fielded systems undertaken to extend the life of the system beyond what was previously planned.

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Demilitarization and Disposal

Demilitarization and disposal occurs at the end of the system’s useful life. During this time in the system's life cycle, the Program Manager must ensure that the material requiring demilitarization is controlled and disposal minimizes DOD’s liability on environmental, safety, security, and health issues.

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Life Cycle Summary Concepts

This section presents the following three concepts: tailoring, milestone reviews, and main activities.

Life-Cycle Summary Concepts—Tailoring

There are many variations on the acquisition life-cycle model. A program should not include an acquisition phase unless it is necessary to reduce risk. Instead, the acquisition strategy is "tailored" to fit the needs of the program.

Phases can be combined or skipped if something has already been developed and is a nondevelopmental item or if technical maturity is sufficient.

Life-Cycle Summary Concepts—Milestone Reviews

Throughout the acquisition life cycle the participants must assess whether or not to proceed with the program. At a milestone review, the Milestone Decision Authority considers these three questions:

- Does past performance (i.e., test results, studies, and assessments) warrant proceeding to the next phase?
- Are plans for the future feasible?
- What are the potential risks to the program and how should we deal with those risks?

Life-Cycle Summary Concepts—Main Activities

Regardless of the number of phases a program has, each phase involves the following three main activities:

- Work is performed.
- Information is generated and shared.
- Reviews and meetings track progress and issue direction.

Specific activities vary depending on which phase a program is in.

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What Is an Acquisition Program Baseline?

DOD 5000.2-R states that every acquisition program shall establish an acquisition program baseline (APB) to document the cost, schedule, and performance thresholds and objectives of that program beginning at program initiation. Everyone in the program's chain of authority commits to meeting the cost, schedule, and performance thresholds and objectives established in the APB.

The APB is a formal agreement created and signed by the Program Manager and those in the chain of authority up to the Milestone Decision Authority.

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What Are Exit Criteria?

Exit criteria are program-specific accomplishments that must be satisfactorily demonstrated before an effort or program can progress further in the current acquisition phase, or transition to the next acquisition phase. Typically, exit criteria require that the demonstration of a level of performance be documented.

For each life-cycle phase, exit criteria are:

- Formulated by appropriate Integrated Product Teams (IPTs).
- Proposed by the Program Manager at the end of the previous phase.
- Included in the Acquisition Decision Memorandum signed by the Milestone Decision Authority.

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What Is an Acquisition Strategy?

An Acquisition Strategy is a business and technical management approach designed to achieve

program objectives within the resource constraints imposed. The Program Manager prepares an acquisition strategy that encompasses the entire system life cycle, from program initiation through production, fielding/deployment, and operational support. The acquisition strategy is approved through the acquisition chain of command and is updated as more is learned about the system, as well as for each milestone review.

An acquisition strategy provides:

- A foundation for planning, directing, contracting for, and managing a program.
- A master schedule for research, development, test, production, fielding, modification, postproduction management, and other activities essential for a program's success.
- A unique, tailored, top-level master plan that guides the entire program.

Tailoring the Acquisition Strategy

When it comes to acquisition strategies, no one size fits all. Each strategy is tailored to fit the unique technical, resource, and fiscal constraints of a program. Program structure charts are used to graphically depict the key elements of each acquisition strategy.

Traditional Development Acquisition

In the conventional approach, all four phases are conducted and separated by milestone reviews. Expect to use this acquisition strategy with a technically complex program, such as peacekeeper missile, F-22 fighter, or M1A1 tank.

Mature Technology Acquisition

In this approach, there is no need for PDRR because the technology is already proven. Milestones 0, I, and II are combined. As a result, the program moves directly to EMD. Examples include F-15 upgrade programs and F-18 upgrade programs.

Nondevelopmental Item (NDI) Acquisition

If a nondevelopmental item is acquired, PDRR and EMD do not need to be conducted. The program will skip Milestones I and II, and go right to production after CE. This acquisition strategy was used to acquire 9mm handguns.

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Lesson 4: Systems Acquisition Management: Organizations and Acquisition Categories

Organizations Involved in Defense Acquisition

There are three primary organizations that influence the defense acquisition community: the Executive Branch, Congress, and industry. Each participant plays a significant role in the acquisition process.

The Executive Branch

The Executive Branch includes the President, the Department of Defense, the Office of Management and Budget (OMB), the Department of State, and the National Security Council (NSC). These participants:

- Formulate, direct, and execute national security policy.
- Issue directives and regulations.
- Exercise command and control of unified commands through the Chairman of the Joint Chiefs of Staff (CJCS).
- Make decisions on defense acquisition programs.
- Sign legislation into law.
- Field weapon systems to counter threats.

The Congress

Congressional activities include:

- Representing interests of their constituents.
- Debating, voting, and passing legislation.
- Setting resource ceilings (e.g., for manpower and equipment).
- Raising taxes and providing budget authority.
- Balancing defense and social needs.
- Controlling public debt.

Congress uses various committees to assist with the legislative oversight of defense activities.

Industry

The defense industry (contractors) includes large and small organizations that provide goods and services to DOD. These organizations:

- Represent interests of their owners or stockholders.
- Respond to requests for proposals.

- Propose solutions.
- Design and produce systems.
- Upgrade and support systems.
- Generate profit and growth.

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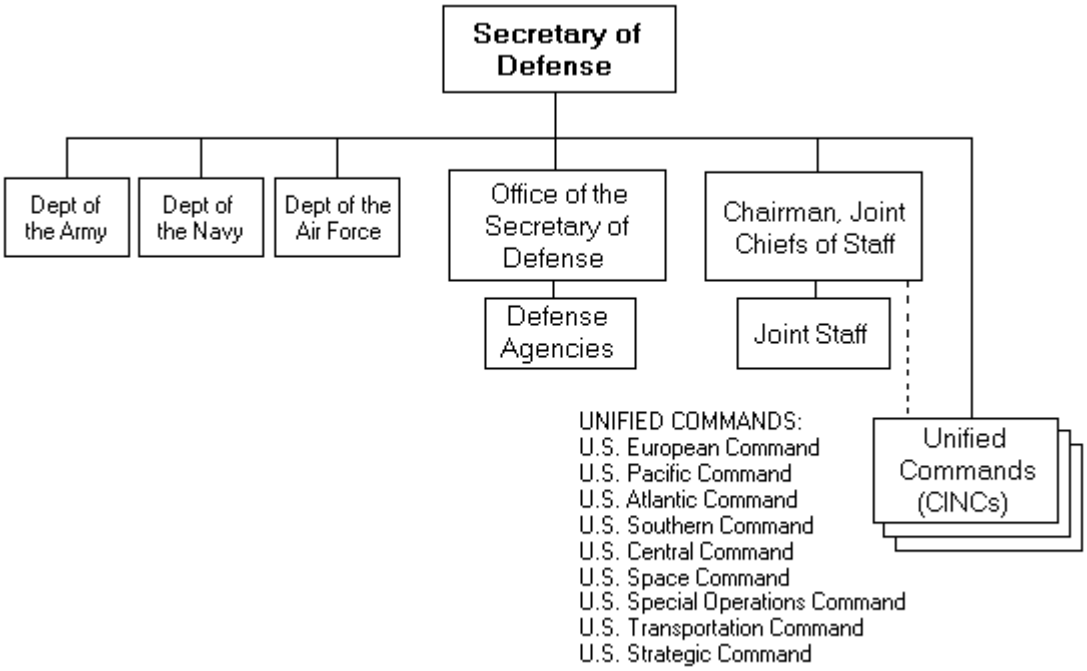
Department of Defense Organization

- Secretary of Defense
- The Office of the Secretary of Defense
- Under Secretary of Defense (USD) Comptroller
- USD (Policy)
- Director, Program Analysis & Evaluation
- Director, Operational Test & Evaluation
- Assistant Secretary of Defense Command, Control, Communications and Intelligence (ASD (C3I))
- Under Secretary of Defense Acquisition and Technology (USD (A&T))
- Defense Acquisition Board (DAB)

Before looking at the different acquisition categories, it is important to understand the role of the key players who have an impact on the acquisition workforce and programs and the organizational structure within the Department of Defense.



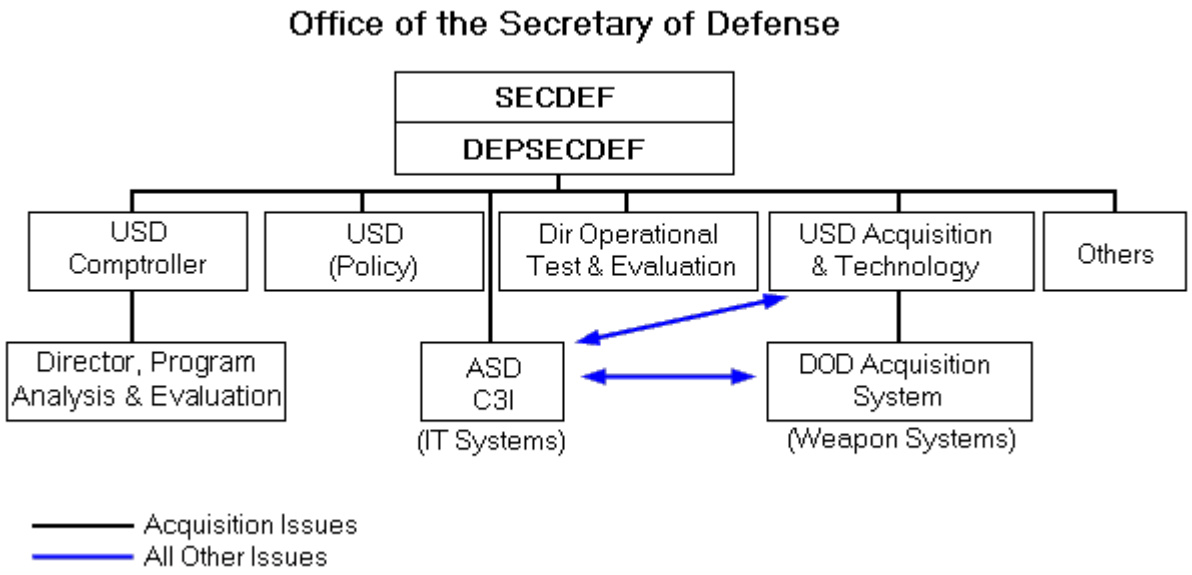
Secretary of Defense

The Department of Defense is headed by the Secretary of Defense, also known as the SECDEF. The SECDEF is a Cabinet-level position created by the National Security Act of 1947.

The Secretary of Defense is "the principal assistant to the President in all matters relating to the national security", is responsible for establishing the "general policies and programs" for the military departments and agencies, and exercises "general direction, authority, and control" over those entities.

The Office of the Secretary of Defense

The Secretary of Defense staff members are referred to as the Office of the Secretary of Defense (OSD). These staff members help the SECDEF manage the Armed Forces of the United States.



USD Comptroller

The Under Secretary of Defense (USD) Comptroller controls the budget and the release of funds. The USD Comptroller is responsible for the budgeting phase of the Planning, Programming, and Budgeting System (PPBS).

USD (Policy)

USD (Policy) is charged with approving certain aspects of programs involving other nations and is responsible for the planning phase of PPBS.

Director, Program Analysis & Evaluation

The Director, Program Analysis & Evaluation is responsible for the programming phase of PPBS. The Director conducts program analyses and reviews to ensure money is spent properly and in a timely manner.

Director, Operational Test & Evaluation

The Director, Operational Test & Evaluation provides independent assessment of the operational effectiveness and suitability of new weapon systems. The Director sends Operational Test & Evaluation reports directly to the SECDEF and Congress.

Assistant Secretary of Defense Command, Control, Communications, & Intelligence (ASD (C3I))

ASD (C3I):

- Is Principal Staff Assistant (PSA) and advisor to the SECDEF and DEPSECDEF for information technology.
- Serves as the DOD's Chief Information Officer (CIO).
- Establishes software policy and practices.

Under Secretary of Defense Acquisition and Technology (USD (A&T))

The USD (A&T):

- Is the Defense Acquisition Executive (DAE).
- Establishes policy and procedures for DOD acquisition matters.
- Chairs the Defense Acquisition Board (DAB).
- Makes program milestone decisions for Major Defense Acquisition Programs (MDAPs).

Defense Acquisition Board (DAB)

The DAB is the Department's senior-level forum for advising the USD (A&T) on critical decisions concerning designated acquisition programs. The DAB is composed of the Department's senior acquisition officials as well as a user representative (Vice Chief, Joint Chiefs of Staff).

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What Are Acquisition Categories?

Acquisition categories, or ACATs, are established to determine the level of management review, decision authority, and applicable reporting requirements for a program. The ACAT designation determines the level of review and types of decisionmakers involved in the program. DOD 5000.2-R specifies the criteria for acquisition categories.

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Types of Acquisition Categories

There are ACATs for weapon systems and Command, Control, Communications, Computers, and Intelligence (C4I) Systems as well as for Automated Information Systems (AIS).

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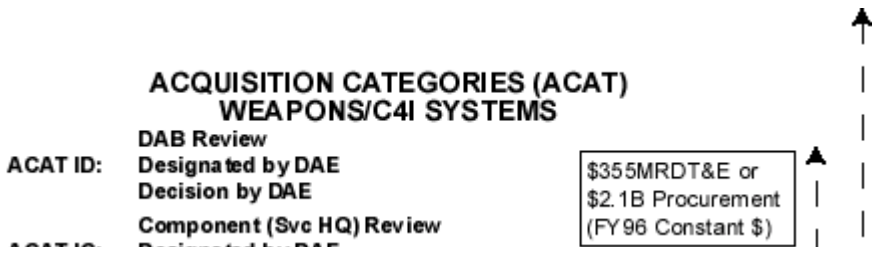
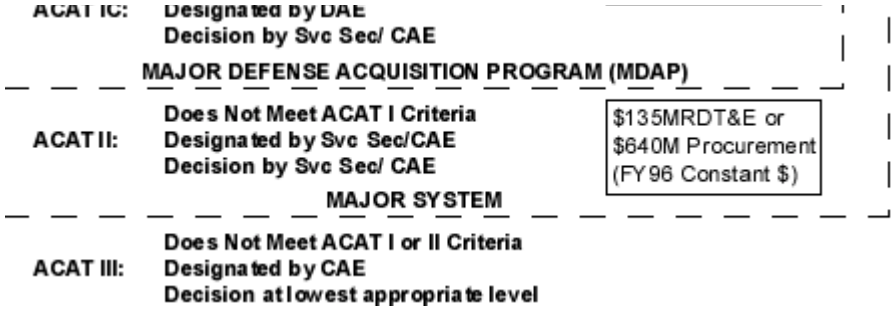
What Are the Weapons/C4I Systems Acquisition Categories?

ACATs for weapons systems and C4I systems are divided into three main categories.

- ACAT I (ID + IC)
- ACAT II
- ACAT III





ACAT I Programs

ACAT I programs are Major Defense Acquisition Programs. An MDAP is defined as a program estimated by the Under Secretary of Defense (Acquisition & Technology) to require eventual expenditure for:

- Research, development, test, and evaluation (RDT&E) of more than $355 million (FY 1996 constant dollars), or
- Procurement of more than $2.1 billion (FY 1996 constant dollars).

ACAT I programs also include any program designated by the USD (A&T) to be an ACAT I (e.g., because of Congressional interest, international considerations).

ACAT I Program Subcategories

The USD (A&T) designates programs as ACAT ID or ACAT IC.

- For ACAT ID the Milestone Decision Authority (MDA) is USD (A&T). The "D" in ACAT ID refers to the Defense Acquisition Board, which advises the USD (A&T) at milestone reviews.

- For ACAT IC the MDA is the DOD Component Head or, if delegated, the DOD Component Acquisition Executive (CAE). The "C" refers to Component.

DOD Component Acquisition Executive (CAE)

A CAE is a single official within a DOD component who is responsible for all acquisition functions within that component. This includes Service Acquisition Executives (SAEs) for the military departments and acquisition executives in other DOD components, such as the U.S. Special Operations Command (USSOCOM) and Defense Logistics Agency (DLA), who have acquisition management responsibilities.

ACAT II Programs

ACAT II programs are defined as those acquisition programs that do not meet the criteria for an ACAT I program, but do meet the criteria for a Major System. The Milestone Decision Authority for ACAT II programs is the CAE.

ACAT II Major Systems

A Major System is defined as a program estimated by the DOD Component Head to require eventual expenditure for:

- Research, development, test, and evaluation of more than $135 million in FY96 constant dollars, or
- Procurement of more than $640 million in FY96 constant dollars.

Major Systems also include those programs designated by the DOD Component Head to be ACAT II.

ACAT III Programs

ACAT III programs are defined as those acquisition programs that do not meet the criteria for an ACAT II (for MDAPs) or ACAT IA (for AISs).

The Milestone Decision Authority is designated by the CAE and shall be at the lowest appropriate level.

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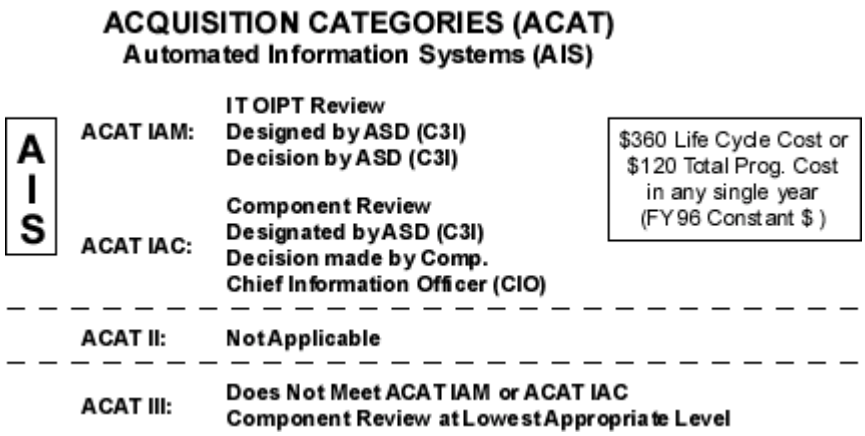
What Are the Automated Information Systems (AIS) Acquisition Categories?

ACATs for Automated Information Systems (AIS) are divided into two main categories:

- ACAT IA (IAM + IAC)
- ACAT III



ACAT IA Programs

ACAT IA programs are Major Automated Information Systems (MAISs). A MAIS is estimated by the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence (ASD (C3I)) to require:

- Program costs for any single year in excess of $30 million (FY96 constant dollars), or
- Total program costs in excess of $120 million (FY96 constant dollars), or
- Total life cycle costs in excess of $360 million (FY96 constant dollars).

ACAT IA programs also include those programs designated by the ASD (C3I) to be ACAT IA.

ACAT IA Subcategories

ACAT IA programs have two subcategories:

- ACAT IAM, for which the Milestone Decision Authority (MDA) is the Office of the Secretary of Defense (OSD) Chief Information Officer (CIO), the ASD (C3I).

- ACAT IAC, for which the MDA is the DOD Component Chief Information Officer (CIO). The "C"

in IAC refers to Component.

The ASD (C3I) designates programs as ACAT IAM or ACAT IAC.

ACAT III Programs

ACAT III programs are defined as those acquisition programs that do not meet the criteria for an ACAT IA. This category includes less-than-major AISs. There is no ACAT II for AISs.

The Milestone Decision Authority is designated by the DOD Component Acquisition Executive (CAE) and shall be at the lowest appropriate level.

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Who Determines the ACAT?

The user who originates a Mission Need Statement (MNS) determines if the need could potentially result in the initiation of a new program and makes a recommendation to the Milestone Decision Authority. An identified need should be considered as a potential ACAT I when:

- It requires new, leading-edge technologies and extensive development.
- It results in the initiation of a major performance upgrade to an existing system that is fielded in significant quantities.
- There is a doubt regarding the appropriate category.

However, the final ACAT determination is made by the appropriate MDA at Milestone 0 Review.

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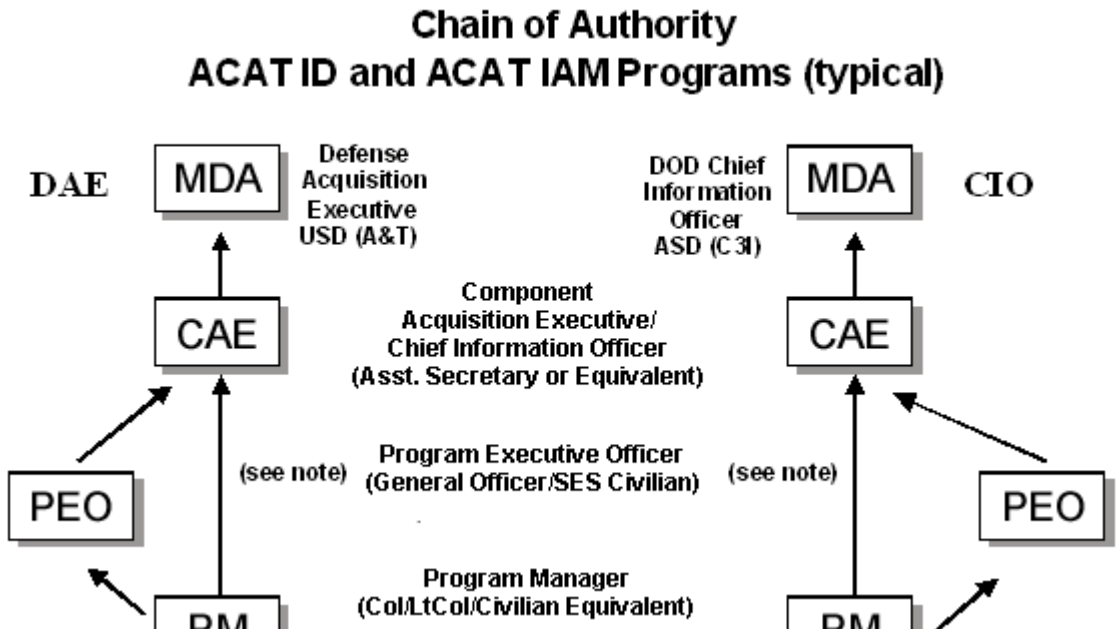
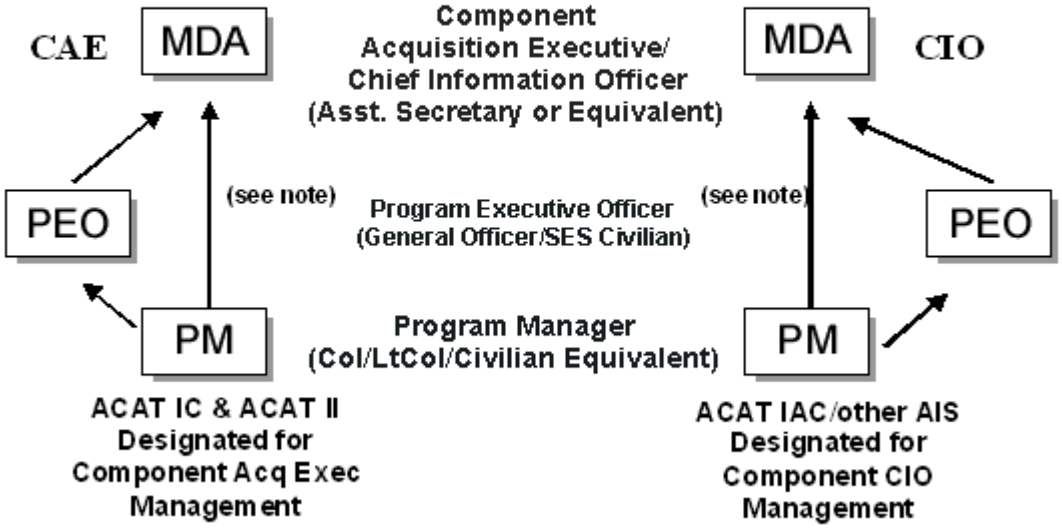
ACATs and Chain of Authority

For all acquisition programs, the review process depends upon the projected spending level or the level of interest a program may have within DOD. The guiding principle in all cases is that there should be no more than two levels of review between a Program Manager (PM) and the MDA.



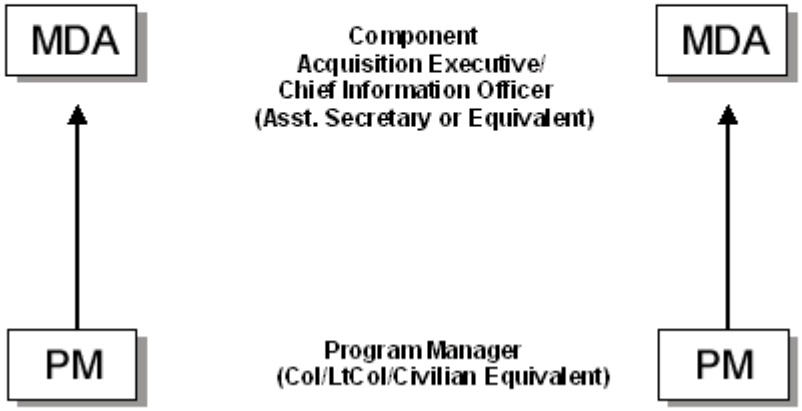
Note: Some PMs report direct and do not go through a PEO.

Chain of Authority (cont.)
ACAT IC, ACAT IAC, and ACAT II Programs (typical)



Note: Some PMs report direct and do not go through a PEO.

Chain of Authority (cont.)
ACAT III/IV* Acquisition Programs (typical)



* Army, Navy, and Marine Corps use ACAT IV designation

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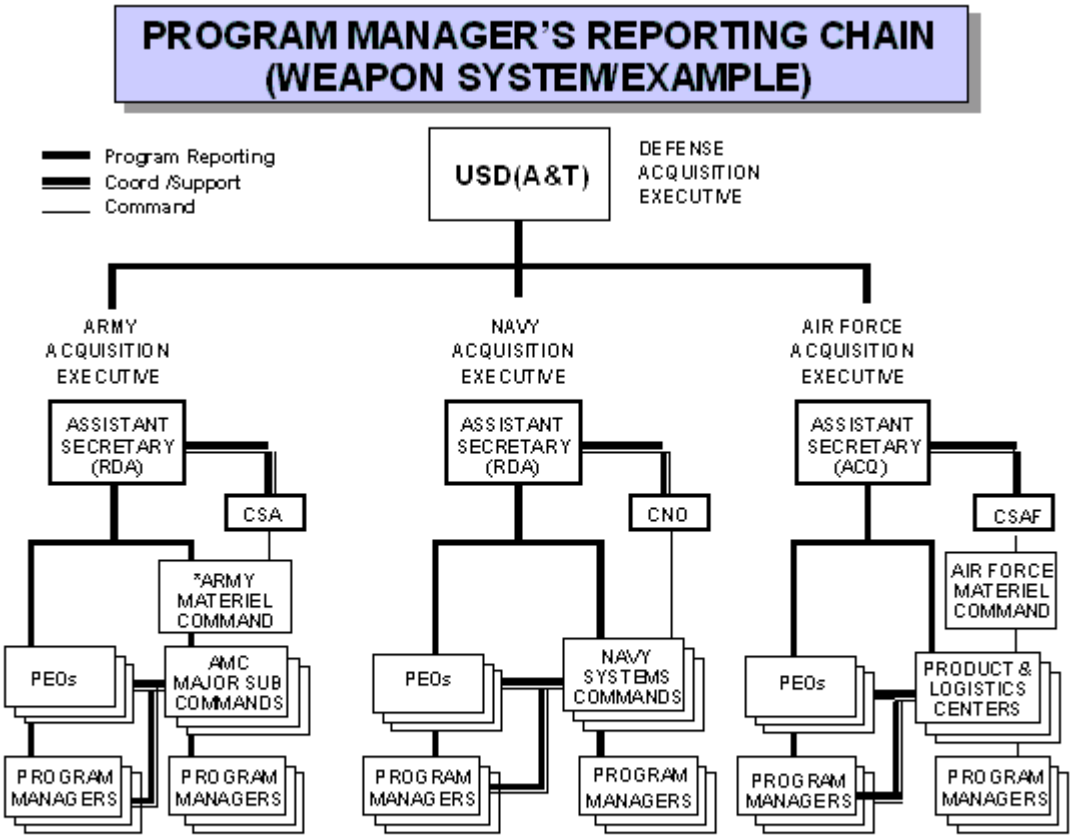
Program Manager's Reporting Chain

Although the Defense Acquisition Executive (DAE) is the top-level official for all defense acquisitions, the PM is in charge of all aspects of a particular program. As part of the acquisition workforce, you provide support to the PM, if not directly, then through a matrix organization or an Integrated Product Team (IPT).



Not Shown: Army Space & Strategic Defense Command, US Marine Corps and Defense Agency Program Managers, US Special Operations Command.

Note: Some PMs report to a major sub-command, product and logistics center, or systems command instead of a PEO.

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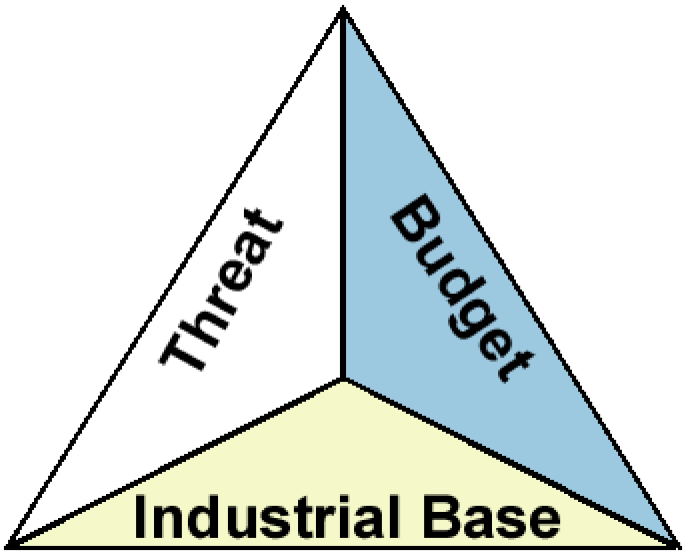
REVIEW RESOURCES

Lesson 5: Systems Acquisition Management: Acquisition Reform

Changing Defense Environment



Changing Defense Environment: Threat

Today, it is more challenging to identify the threat to our national security. Old enemies are gone, and technology poses new types of threats. For example, viruses and computer hackers can be serious threats to information systems that are critical to national security as well as battlefield operations.

Changing Defense Environment: Budget

Defense budgets are shrinking or holding constant. Modernization funds are falling behind demand.

One major driver behind Acquisition Reform is to generate savings to pay for acquisition programs that maintain force readiness levels with modern, supportable systems.

Changing Defense Environment: Industrial Base

Corporate mergers and less demand may cause the number of suppliers to dwindle. Fewer suppliers could mean higher costs, or even worse, no sources to build or maintain systems.

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Acquisition Reform: Major Areas of Focus

For Acquisition Reform to succeed it must have a wide focus. Some of the areas covered by

Acquisition Reform are:

- Supporting the Warfighter
- Improving Business Processes
- Reducing Life-Cycle Costs
- Offering Incentives
- Reforming Regulations
- Managing the Workforce
- Conducting Pilot Programs

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Supporting the Warfighter

The intent of Acquisition Reform is to provide better support to the warfighter by fostering open communications among key stakeholders (i.e., users, acquisition managers, and contractors) when developing system requirements documents and throughout the life cycle to ensure user needs are met.

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Improving Business Processes

Acquisition Reform encourages the elimination of cumbersome, outdated, and bureaucratic ways of doing business. The Federal Acquisition Streamlining Act of 1994 and the National Defense Authorization Act of 1996 made numerous changes in acquisition business processes, including:

- Emphasizing the use of electronic commerce.
- Raising the threshold for using simplified acquisition procedures.
- Using commercial specifications instead of traditional military specifications.
- Allowing a Single Process Initiative, which is a process for making block changes to existing contracts to replace multiple Government-unique manufacturing and management systems with common, facility-wide systems.
- Using market research to determine if a commercial or nondevelopmental item will satisfy the requirements.

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Reducing Life-Cycle Costs

Most Acquisition Reform tools help reduce or avoid life-cycle costs if they are implemented properly. Costs must be cut to compensate for shrinking budgets. Some initiatives that help reduce life-cycle costs include:

- Increasing Use of Commercial Specifications
- Cost As an Independent Variable (CAIV)
- Commercial and Nondevelopmental Items
- Value Engineering
- Earned Value
- Open Systems
- Single Process Initiative
- Past Performance
- Modeling and Simulation
- Integrated Process and Product Development (IPPD)

Increasing Use of Commercial Specifications

The cancellation of numerous military specifications and standards has created considerable savings, because multiple processes have been eliminated.

Cost As an Independent Variable (CAIV)

CAIV means setting life-cycle cost objectives for an acquisition up front and early. The process uses available dollars as an independent variable to determine cost, schedule, and performance tradeoffs early in and throughout the acquisition process.

Commercial and Nondevelopmental Items

Commercial items are "off-the-shelf" items. Nondevelopmental items are those previously developed by Federal, State, local, or allied governments to satisfy requirements. The potential benefits include not only lower life-cycle costs but also more rapid deployment, proven capability, and improved quality.

Value Engineering

Value engineering allows contractors to propose changes to a product and/or process and in turn reap some of the benefits.

Earned Value

Earned Value management allows both the contractor and the Government to use the same data for gathering insight into program progress and the contractor’s planning process.

Open Systems

Open Systems involves designing systems to remain flexible enough to incorporate changes without a major reinvention of the basic system.

Single Process Initiative

Single Process Initiative is a process for making block changes to existing contracts to replace multiple Government-unique manufacturing and management systems with common, facility-wide systems.

Past Performance

DOD is increasing the use of past performance as part of the source selection criteria used to choose best-value contractors. Using this criterion can potentially create savings by incentivizing contractors to improve performance to help future contracts.

Modeling and Simulation

Models and simulations are efficient and cost-effective sources of information that can help acquisition programs reduce cost, schedule, and performance risk. Models and simulations can also shorten life-cycle time, accelerate understanding of the system, and reduce expenditures of resources.

Integrated Process and Product Development (IPPD)

Integrated Process and Product Development (IPPD) saves costs by ensuring a "systems" approach to acquisition. IPPD helps prevent additions and/or changes late in the life cycle for factors "forgotten"

earlier, such as supportability, testability, and producibility.

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Offering Incentives

Acquisition Reform provides incentives to contractors. Contractors are provided incentives by sharing the savings resulting from their proposed changes in a product or process.

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Reforming Regulations

Acquisition Reform led to the following reforms in DOD regulations:

- The DOD 5000 documents were rewritten to minimize restrictive procedures and formats. By reducing the list of mandatory practices and removing discretionary items, the new 5000 documents are greatly reduced in bulk.
- Changes were made in the Federal Acquisition Regulation (FAR) to improve and streamline contracting and accounting processes.
- The Defense Acquisition Deskbook was created to serve as the repository for the discretionary information that was eliminated from the regulations. The Deskbook also contains the mandatory practices and has a searchable reference library.

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Managing the Workforce

The implementation of Acquisition Reform depends on the quality of the acquisition workforce. Enhancing the quality of the acquisition workforce includes:

- Mandatory training, education, experience, and certification requirements specified by the Defense Acquisition Workforce Improvement Act (DAWIA).
- New practices (e.g., flexible hours, telecommuting, consolidating, rightsizing) that allow managers to make the most of limited monetary and personnel resources.
- Use of Integrated Product Teams (IPTs) to implement IPPD.

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Conducting Pilot Programs

Pilot programs are used to innovate and highly tailor program strategies used in business processes of the acquisition process. Pilot programs are encouraged to maximize the use of commercial, industrial practices. Some of the objectives include implementing regulatory and statutory streamlining and eliminating unique Government requirements such as military specifications and military standards. The Joint Air-to-Surface Standoff Missile (JASSM) is an example of a pilot program.

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Why IPPD?

The ultimate goal of DOD acquisition is to provide the warfighters with quality equipment and systems

at an affordable cost and on a schedule that is responsive to the need. DOD has adopted the IPPD process to help meet this goal.

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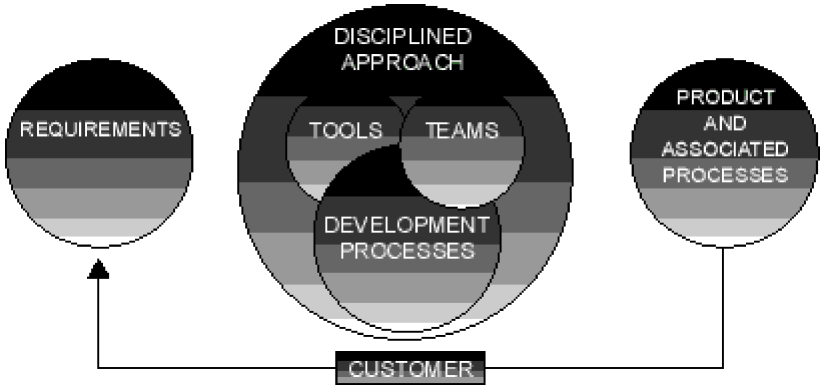
What Is IPPD?

- Requirements
- Disciplined Approach
- Tools
- Teams
- Development Processes
- Product and Associated Processes
- Customer

DOD defines IPPD as "a management process that integrates all activities in the diagram below from product concept through production/field support, using a multifunctional team, to simultaneously optimize the product and its manufacturing and sustainment processes to meet cost and performance objectives." A generic iterative IPPD process is shown below.



Requirements

Requirements are generated by the customer through negotiations among many parties, each with serious and important concerns. IPPD emphasizes understanding that customer needs are essential. Integrating the user's requirements, logistical requirements, and the acquirer's budgetary and scheduling constraints is a fundamental challenge in DOD acquisition and is a key objective of IPPD.

Disciplined Approach

Disciplined Approach includes five general activities:

- Understanding the requirements.
- Outlining the approach.
- Planning the effort.
- Allocating resources.
- Executing and tracking the plan.

Decisions made using this approach should be reevaluated as a system matures and circumstances (budgetary, threat, technology) change. A disciplined approach provides a framework for utilizing tools, teams, and processes in a structured manner that is responsive to systematic improvement efforts.

Tools

Tools in this IPPD process include documents, information systems, methods, and technologies that can be fit into a generic shared framework that focuses on planning, executing, and tracking. Tools help define the product(s) being developed, delivered, or acted upon, and relate the elements of work to be accomplished to each other and to the end product.

Teams

Teams are central to the IPPD process. Teams are made up of everyone who has a stake in the outcome or product of the team, including the customer and suppliers. Collectively, team members should represent the know-how needed and have the ability to control the resources necessary for getting the job done. Teams are organized and behave so as to seek the best value solution to a product acquisition.

Development Processes

Development Processes are those activities that lead to both the end product and its associated processes. To ensure efficient use of resources, it is necessary to understand what activities are necessary and how they effect the product and each other. Examples include requirements analysis, configuration management, and detailed design drawings.

Product and Associated Processes

Product and Associated Processes include what is produced and provided to the customer. Customer satisfaction with the product, in terms of mission effectiveness, as well as operating and support aspects and costs, is the ultimate measure of the team's success.

Customer

The customer is the user and a team member and also the ultimate authority regarding the product. Any changes to the formal requirements driving the product/process development must come through negotiation with the customer.

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IPPD Benefits

Applying the IPPD management philosophy can result in significant benefits to the customer, DOD, and industry. The primary benefits are reduced cost and schedule time, increased quality, and reduced risk.

These gains are realized by the early integration of business, contracting, manufacturing, testing, training, and support considerations in the design process, resulting in fewer costly changes made later in the process.

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What Are IPTs?

Integrated Product Teams (IPTs) are the means through which IPPD is implemented. IPTs are cross-functional teams that are formed for the specific purpose of delivering a product for the customer. IPT members should have complementary skills and be committed to a common purpose.

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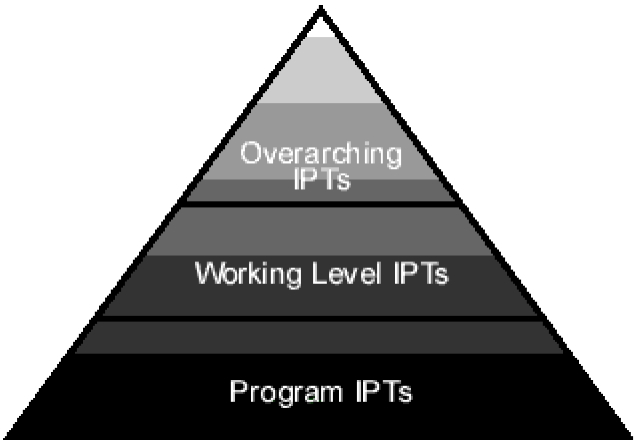
IPT Levels

For any major defense Acquisition Program there are generally three levels of Government-operated Integrated Product Teams.



Program IPTs

Program IPTs are formed by the Program Manager and often include the supporting contractor. These IPTs:

- Provide advice and recommendations to the Program Manager.
- Work day-to-day issues with the contractor.
- Integrate the Government and contractor efforts.
- Report program status and issues.

Working Level IPTs (WIPTs)

Working Level IPTs:

- Are formed in specific functional areas (e.g., cost, testing, contracting, engineering).
- Are led by the Program Manager or designated representative.
- Assist in developing strategies and program plans.
- Establish action plans and milestones.
- Surface and resolve issues.
- Refer unresolved issues to the Overarching IPT.

Overarching IPTs (OIPTs)

Overarching IPTs are formed at the highest levels with the Office of the Secretary of Defense to support all major acquisition programs. The primary roles of an OIPT are to:

- Provide strategic guidance.
- Help resolve issues early as a program proceeds through its acquisition life cycle.
- Elevate unresolvable issues to the DAB/IT OIPT.

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Lesson 6: Team Building

Teamwork Mandate

DOD 5000.2-R states the following:

- The Department of Defense shall perform as many acquisition functions as possible, including oversight and review, using Integrated Product Teams (IPTs).
- These IPTs shall function in a spirit of teamwork with participants empowered and authorized, to the maximum extent possible, to make commitments for the organization or functional area they represent.

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Integrated Product Team (IPT) Operating Principles

IPTs are under the following broad principles:

- Open discussions with no secrets.
- Qualified, empowered team members.
- Consistent, success-oriented, proactive participation.
- Continuous "up-the-line" communications.
- Reasoned disagreement.
- Issues raised and resolved early.

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Team Development

Over the years, social psychologists have observed the "building" of a team. According to Bruce W. Tuckerman's research, every team goes through the following stages:

1. Forming
2. Storming
3. Norming
4. Performing
5. Adjourning

Stage 1: Forming

During the Forming Stage, the team spends time trying to figure out how to accomplish the tasks and little time actually doing tasks.

Typical emotions include:

- Excitement, anticipation, and optimism.

- Pride in being chosen for the project.
- Initial, tentative attachment to the team.
- Suspicion, fear, and anxiety about the job ahead.

Typical group behaviors include:

- Attempts to define the task and to decide how to get it done.
- Attempts to determine acceptable group behavior.
- Decisions about what information to gather.
- Lofty, abstract discussions.
- Complaints about the tasks or organization.

Stage 2: Storming

During the Storming Stage, the team begins to realize that the task at hand is different or more difficult than they had imagined.

Typical emotions include:

- Resistance to the task and to new approaches.
- Uncertainty about the team's success.
- Impatience, hostility, and discomfort.
- Disunity, tension, and jealousy.

Typical group behaviors include:

- Arguing among team members even when they agree.
- Defensiveness and competition; factions and "choosing sides."
- Questioning the wisdom of superiors.
- Establishing unrealistic goals.
- Concern about excessive work.
- Perception of a pecking order.

Stage 3: Norming

During the Norming Stage, the team reconciles competing loyalties and responsibilities. The team develops spoken or unspoken rules on how to proceed.

Typical emotions include:

- A new ability to express criticism constructively.
- Acceptance of membership in the team.
- Relief that is seems that everything is going to work out.
- Renewed energy.
- Common spirit and team cohesion.

Typical group behaviors include:

- Attempts to achieve harmony by avoiding conflicts.
- More confiding and sharing of information.
- Establishment and maintenance of spoken or unspoken ground rules and group norms.
- More acceptance of all team members and their ideas.

Stage 4: Performing

During the Performing Stage, team members work collaboratively to get the job done and solve problems.

Typical emotions include:

- Acceptance of other team members' strengths and weaknesses.
- Satisfaction with the team's progress.
- Pride in being part of the team.
- Excitement.

Typical group behaviors include:

- Taking actions to prevent or work through group problems.
- Balancing the behaviors for maintaining effective team relations with the behaviors required to get the job accomplished.
- Taking steps to maintain close attachment within the team.

Stage 5: Adjourning

During the adjourning stage, the team is preparing for the group's dissolution.

Typical emotions include:

- Melancholy acceptance of the team's separation.
- Pride in the team's success.

Typical group behaviors include:

- Congratulating fellow team members.
- Bidding farewells.

Team Development Stages: Summary Concepts

Although all effective teams go through each stage, the time it takes each group to complete a stage varies greatly.

The goal is for the team to reach the Performing Stage and remain in that stage until the work is accomplished.

Not every team achieves and stays in the Performing Stage. Changes in team members, new work assignments, policy modifications, or other events may cause a team to return to an earlier stage. When this happens, team members need to work together to reconfirm the commitment (forming), clarify roles/relationships (storming), and reestablish group rules (norming).

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Team Decision Making: Advantages and Disadvantages

Advantages of Team Decision Making

- Greater commitment from those implementing the decision.
- Allows for more points of view to be considered.
- There may be reasoned disagreement.
- More creative options may be generated.

Disadvantages of Team Decision Making

- Can be time consuming.
- The team needs to be in the norming or performing stage to work well together.

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What is Consensus?

Team decisions are based on reaching consensus. Consensus means:

"We can live with ‘x’ as a solution, and we all agree to go along with whatever it takes to implement it."

Consensus does not mean that everyone gets his or her wishes. Consensus works when team members are willing to compromise with one another.

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Consensus-Building Tips

- Be open and honest when expressing your ideas and opinions.
- Avoid judging ideas instantaneously. Let team members state their cases and ask questions.
- Be willing to compromise and to be flexible.
- Analyze decisions and problems in a systematic manner.
- Agree at the beginning on the issue you are analyzing and your goal.
- Share the same information with all team members.
- Allow enough time to reach consensus, but know when enough time has passed.

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Tips for Being an Effective Team Member

- Shared Responsibility: Take responsibility for the overall team performance, not just your specialty area.
- Commitment to Team Purpose: Make sure you understand the team goals and make a commitment to them.
- Open Communication: Help foster trust among team members by providing honest, open feedback and constructively airing differences.
- Resources and Talents: Allow the team to match your individual strengths to appropriate tasks and share your talents freely.
- Team Evaluation: On a frequent basis, work with other team members to assess how well the team is doing and generate suggestions for improving the team's performance.

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Lesson 7: The Requirements Generation System

Requirements Generation System

By analyzing their mission, users identify deficiencies in their operations as well as opportunities for greater efficiency. The Requirements Generation System is the process used to translate analysis of identified deficiencies into requirements forming the basis of all acquisition programs. The Requirements Generation System is "owned" and operated by the users of the developed systems/warfighters.

The Requirements Generation System has four separate phases:

- Definition
- Documentation
- Validation
- Approval

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Definition Phase

The Definition Phase defines, describes and justifies a mission need that will satisfy a deficiency in the user's capability or exploit a technological opportunity. This phase has two fundamental steps: the Mission Area Analysis (MAA) and the examination of solutions to any deficiency identified in the MAA.

- Mission Area
- Mission Area Analysis (MAA)
- Solution to Deficiency
- Threat versus Capability
- Future Threats
- Current and Projected Capabilities
- Opportunities for Change
- Advanced Technology
- Policy Changes
- Cost Reduction Opportunities
- Deficiencies or Opportunities
- Possible Solution to Deficiencies

Mission Area

A mission area is a segment of the defense mission as established by the Secretary of Defense. Each DOD component has mission areas (e.g., Navy—antisubmarine warfare, Army—ground combat) for which it must equip its forces.

Mission Area Analysis (MAA)

MAA is the process by which warfighting deficiencies are determined, technological opportunities for

increased system effectiveness and/or cost reduction are assessed, and mission needs are identified.

Solution to Deficiency

Mission Needs identified in the Mission Area Analysis are examined to determine if they can be satisfied through non-materiel solutions such as changes in doctrine, tactics, training, or organization. If this is not feasible, then materiel solutions may be considered, and the need will be documented in a Mission Need Statement.

A non-materiel solution is preferred over the materiel solution, since it is usually less expensive, and usually can be implemented in less time. Once it has been identified that a materiel solution is required to satisfy the user's need, then that need must be documented using the next phase of the Requirements Generation System, the Documentation Phase.

Threat versus Capability

By comparing the projected threats with current and projected military capability, users identify mission deficiencies or needs.

Future Threats

Future threats are the sum of the potential strengths, capabilities, and strategic objectives of any adversary that can limit or negate U.S. mission accomplishment or reduce force, system, or equipment effectiveness.

Examples we face today include:

- Terrorism
- Ethnic/Religious Conflicts
- Rogue Nations
- Narcotics Traffic
- Military Operations in Urban Terrain
- Information Warfare
- Technology Transfer

Current and Projected Capabilities

Current and projected capabilities are the ability of the user's forces today and in the future to accomplish the mission.

Examples include:

- F-22 Advanced Tactical Fighter
- MV-22-Osprey Joint Advanced Vertical Lift Aircraft
- Joint Strike Fighter
- NSSN-New Attack Submarine
- FMTV-Family of Medium Tactical Vehicles

Opportunities for Change

By looking at emerging technologies, changes in policies, or ways to reduce cost, users can identify ways of performing the mission more effectively or efficiently.

Advanced Technology

Advanced Technology results from advancements in science, technology, and engineering that provide breakthrough opportunities for future systems. Examples include:

- Stealth Materials and Techniques
- Advanced Sensor Materials
- Manufacturing Methods
- Information Processing Architectures
- High Strength Materials

Policy Changes

Policy changes are top-level redirection on how the user's forces are to be employed.

Examples include:

- Drug Interdiction
- Peacekeeping Operations such as Haiti and Bosnia
- Adoption of the Strategic Arms Reduction Treaties (START)

Cost Reduction Opportunities

Cost reduction opportunities are strategies that will significantly reduce the cost of operations or ownership of a fielded system.

Examples include:

- Modernizing the engine on the KC-135
- MINUTEMAN III GRP-Guidance Replacement Program
- F/A-18
- Joint Direct Attack Munitions

Deficiencies or Opportunities

A deficiency or opportunity is a result of a Mission Area Analysis which revealed that a new way of accomplishing the mission was needed or possible.

Possible Solutions to Deficiencies

Once a warfighting deficiency or technology is identified, the following question needs to be asked:

> Is this deficiency or opportunity within the user's capability to address by making changes in training, organization, tactics, or doctrine?

If the answer to this question is **yes**—the user can solve the problem by changes in training, organization, tactics, or doctrine—then a non-materiel solution has been found.

If the answer to this question is **no**—the problem cannot be solved through a non-materiel solution—then a materiel solution is needed and the acquisition world gets involved.

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Documentation Phase

Once it has been decided that a materiel solution is required to satisfy the need, it must be

documented. The Documentation Phase of the Requirements Generation System involves the formal preparation and initial review of the Mission Need Statement.

Mission Need Statement (MNS)

The MNS is prepared by the user to document an operational deficiency or technological opportunity that requires a materiel solution. The MNS:

- Is generic, not system specific.
- Describes the need in broad operational terms.
- Is limited to five pages.
- For ACAT I programs, shall identify linkage to the DOD Strategic Plan.
- Is prepared and staffed in accordance with CJCSI 3170.01.

Chairman of the Joint Chiefs of Staff Instruction 3170.01

Formerly known as MOP 77, this CJCS Instruction provides policies and procedures for developing, reviewing, validating, and approving the user's requirement in support of DODD 5000.1 and DOD 5000.2-R and the acquisition process.

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Validation Phase

Validation is a formal review of the requirements document by an operational authority other than the user. At a minimum, the validation authority will:

- Confirm the existence of an identified need and operational requirement.
- Verify that non-materiel solutions are not feasible.
- Assess joint service potential.
- Verify interoperability requirement.

Validation Authority

The person or agency who validates the mission need depends on the Acquisition Category (ACAT) and the service or agency involved.

ACAT I Validation Authority: Joint Requirements Oversight Council (JROC)

The JROC validates all requirements documents if the materiel solution could result in an ACAT I (D or C) program. The JROC members are:

- Vice Chairman of the Joint Chiefs of Staff
- Vice-Chief of each Service:
  - Vice Chief of Staff, Air Force
  - Vice Chief of Staff, Army
  - Vice Chief of Naval Operations
  - Assistant Commandant of the Marine Corps

ACAT IA (M or C) Validation Authority

If the materiel solution could result in a new ACAT IA (M or C) Automated Information System (AIS), then the JROC will evaluate the program to determine if JROC oversight is appropriate or desired and validates the requirement as required.

If JROC oversight is not appropriate or desired, and the materiel solution could result in a new ACAT IA (M or C) Automated Information System, then the appropriate Principal Staff Assistant (PSA) validates the requirement.

OSD Principal Staff Assistants (PSAs)

Principal Staff Assistants are the heads of OSD organizations who report directly to the Secretary of Defense or the Deputy Secretary of Defense. PSAs represent the user community in the functional area under their direction on acquisition and requirements matters.

Validation Responsibility for ACAT II and III Programs

This table identifies who is responsible within each service for validating the requirement of ACAT II and III programs.

Service	Validation Authority
Army	Chief of Staff
Navy	Chief of Naval Operations
Air Force	Chief of Staff
Marine Corps	Commandant of the Marine Corps
Other DOD Agencies	DOD Agencies have similar processes

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Approval Phase

Approval is the formal or official sanction of the identified needs described in the requirements document. The approval authority for all potential ACAT I MNSs is the JROC. The approval authority for all potential ACAT IA MNSs is the PSA or JROC. For potential ACAT II or III MNSs, the service chief or designated authority is the approval authority. After the appropriate authority approves the Mission Need Statement, it comes to the acquisition community for Milestone 0 Review. Each Milestone 0 decision-maker must consider value and affordability factors.

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Concept Exploration Phase

- Concept Exploration (CE) Phase Supporting Activities
- Analysis of Alternatives (AoA)
- The Operational Requirements Document (ORD)
- ORD Thresholds and Objectives
- Key Performance Parameters (KPPs)

The acquisition community holds a formal Milestone 0 Review to accept the Mission Need Statement for study and to determine what minimum alternatives should be considered. A formal memo is written, called an Acquisition Decision Memorandum, to document approval to proceed to the next phase of the acquisition life cycle, the Concept Exploration Phase.

Concept Exploration (CE) Phase Supporting Activities

Following Milestone 0 approval, the program enters the Concept Exploration (CE) Phase. During the CE Phase, the Requirements Generation System continues. Users refine requirements and support various CE activities that culminate with a Milestone I decision on whether to initiate a new acquisition program.

Analysis of Alternatives (AoA)

The AoA assesses the value of the alternatives being considered. During the Concept Exploration Phase, the user produces the AoA, usually with assistance from the developer. The developer, or Developing Activity/Agency (DA), is the command responsible for research and development (R&D) and production of a new item. The AoA, which is part of the Cost As an Independent Variable (CAIV) process, examines alternatives to identify the preferred system to satisfy a mission deficiency, weighs the cost of a system against its operational effectiveness, and provides a basis for comparing alternatives.

The AoA has two objectives: (1) it aids and documents the decisionmaking process by illuminating the risks, uncertainty, and relative advantages and disadvantages of the alternatives being considered; and (2) it fosters joint ownership and affords a better understanding of subsequent decisions by early identification and discussion of reasonable alternatives among the decisionmakers and staff at all levels.

The Operational Requirements Document (ORD)

The ORD is published by the user and further refines the MNS. The ORD:

- Identifies performance parameters to satisfy a mission need.
- Is system specific.
- Is first prepared during the Concept Exploration Phase for use at Milestone I.
- Is updated for and refined prior to each subsequent milestone.
- Is prepared and staffed in accordance with CJCSI 3170.01 and DOD 5000.2-R, Appendix II.

ORD Thresholds and Objectives

The ORD identifies system-specific performance parameters. It does so by identifying two key values, the threshold and objective for each parameter.

The "threshold" is the minimum acceptable value, supported by analysis, to the user for a system capability. Anything less than this may not satisfy the mission need.

The "objective" is the desired value better than the threshold which results in an operationally meaningful, cost-effective, and affordable improvement in capability.

The two values bound the design of the system, yet provide the Program Manager with flexibility to design the system according to the user’s needs.

Thresholds and objective performance values in the ORD shall be CAIV-based, considering the results of the AoA and the impact of affordability constraints.

Key Performance Parameters (KPPs)

Some critical system characteristics may also be Key Performance Parameters (KPPs). KPPs are those capabilities or characteristics so significant that failure to meet the threshold can be cause for the concept or system selection to be reevaluated or the program to be reassessed or terminated. KPPs are extracted from the ORD, and included in the APB. KPPs are validated by the JROC for ACAT I programs.

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Cost As an Independent Variable (CAIV)

Cost, schedule, and performance should be considered when deciding on a system.

In the past, performance and schedule drove the costs of our systems. However, in today's era of ever-tightening budgets, cost has become a much more important factor in acquiring and operating our systems.

CAIV is a process that helps arrive at cost objectives (including life-cycle costs) and helps the requirements community set performance objectives. The CAIV process shall be used to develop an acquisition strategy for acquiring and operating affordable DOD systems by setting aggressive, achievable cost objectives and managing achievement of these objectives. Cost objectives shall also be set to balance mission needs with projected out-year resources, taking into account anticipated process improvement in both DOD and defense industries.

The Milestone Decision Authority establishes CAIV objectives that drive the performance and schedule limits of the system. The CAIV objectives often become key design drivers. Managers should establish aggressive but realistic cost objectives for all programs and follow through by trading off performance and schedule, beginning early in the program, to achieve a balanced set of goals based on MDA guidance.

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Interoperability Requirements

Approval of a requirement also ensures each C4I system contains a requirement for interoperability. "Interoperability" refers to the ability of systems, units, or forces to provide services to or accept services from other systems, units, or forces and to use the services so exchanged to operate effectively together. The term also refers to conditions achieved among communications-electronics systems or items of communications-electronics equipment when information or services can be exchanged directly and satisfactorily between them and/or their users.

Joint warfighting interoperability is a C4I/AIS requirement mandated by OSD Policy. This requirement is not a user option. For a program to receive Interoperability Certification, it must first prove its interoperability on paper, via the Requirements Certification Process.

Later the program's interoperability must be tested in the field during its operational testing phase.

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REVIEW RESOURCES

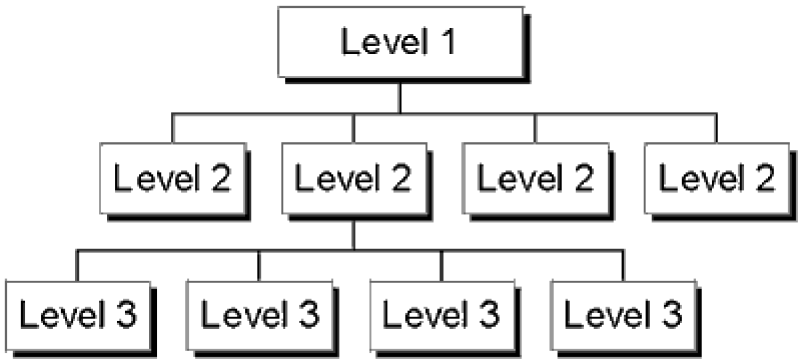
Lesson 8: Work Breakdown Structure

What is WBS?

DOD uses a specific format, called a Work Breakdown Structure (WBS), to:

- Break work into product-oriented elements and work processes.
- Allow acquisition personnel to manage risk at levels lower than the overall system (e.g., at the engine part level of an aircraft).

The WBS is a result of the systems engineering process. Because it shows the relationships among the various products being developed, the WBS is often referred to as a "product-oriented family tree hierarchy." WBS is a valuable program management tool that is used throughout all life-cycle phases, and benefits all acquisition disciplines (e.g., program management, contracting, logistics, finance and budgeting).



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How is WBS Used?

Both contractors and DOD components use WBS to establish a foundation for:

- Developing program and technical plans through the systems engineering process.
- Developing acquisition strategy and contracting documents.
- Establishing schedules.
- Estimating costs and formulating budgets.
- Planning logistics.
- Tracking progress and accomplishments.
- Reporting progress status and analyzing problems.

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Using the WBS: Managing Costs

A WBS can be used to help make program management decisions. For example, if the costs of an element in the WBS are too high, the WBS can be used to identify possible tradeoffs. Identifying and analyzing tradeoffs can help the manager decide how best to stay within budget.

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Using the WBS: Managing Risks

A WBS can be used to identify issues and concerns. By identifying all possible issues and concerns, Program Managers can reduce risk.

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Using the WBS: Assigning Work

The WBS is also useful for determining an acquisition strategy and/or assigning work. The information contained in the WBS can help a Program Manager develop a statement of work that describes what products or services are to be delivered.

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Using the WBS: Scheduling and Tracking

A schedule of key events can be developed for each element in the WBS. Completion of these key events is then tracked.

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Using the WBS: Summary

A WBS is a valuable management tool that:

- Is used throughout all life-cycle phases.
- Manages risk by providing insight into technical aspects of program management.
- Benefits all acquisition disciplines (e.g., program management, contracting, logistics, finance and budgeting, etc.)

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Program and Contract WBSs

The two types of WBSs are:

- Program Work Breakdown Structures
- Contract Work Breakdown Structures

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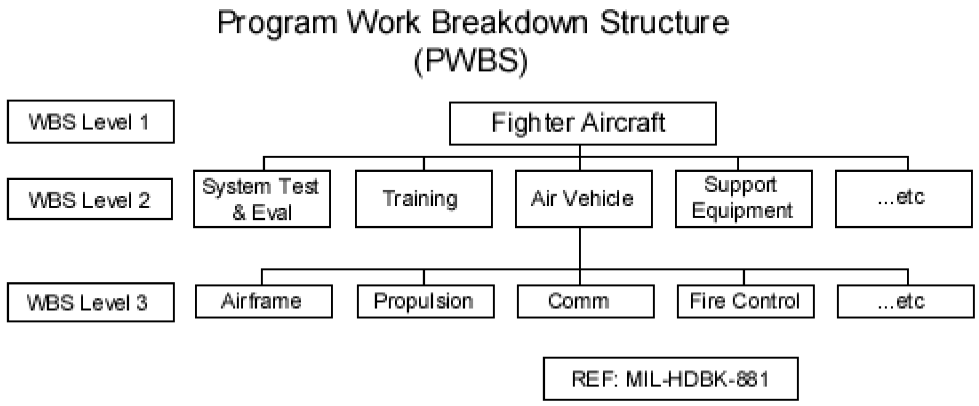
Program WBS

A Program WBS is defined as "the work breakdown that covers the acquisition of a specific defense materiel item and is related to contractual effort." A Program WBS is:

- Tailored to each specific program.
- Prepared and maintained by the Government.
- Provides a basis for developing the Contract WBS.



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Program WBS Levels

Typically, a Program WBS consists of the upper three levels.

WBS Level 1:	The entire defense materiel item.
WBS Level 2:	Major elements of the defense materiel item, which are subordinate to Level 1.
WBS Level 3:	Elements subordinate to Level 2 elements.

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Program WBS Requirement

DOD Regulation 5000.2-R states that:

> "A Program Work Breakdown Structure (WBS) shall be established that provides a framework for program and technical planning, cost estimating, resource allocations, performance measurements, and status reporting." (Para 4.4.1)

DOD Regulation 5000.2-R requires that WBS be used for estimating ACAT I program life-cycle costs.

> "The life-cycle cost estimates shall be explicitly based on the program objectives, operational requirements, contract specifications for the system, and, for ACAT I

programs, a program DOD work breakdown structure (WBS) or, for ACAT IA programs, a life-cycle cost and benefit element structure agreed upon by the IPT." (Para 3.5.1)

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Military Handbook 881

Program offices tailor a Program WBS for each program using the guidance in Military Handbook 881. Work Breakdown Structures can be defined by using the following defense materiel items found in this Handbook:

- Aircraft Systems
- Electronic and Automated Software Systems
- Missile Systems
- Ordnance Systems
- Ship Systems
- Space Systems
- Surface Vehicle Systems

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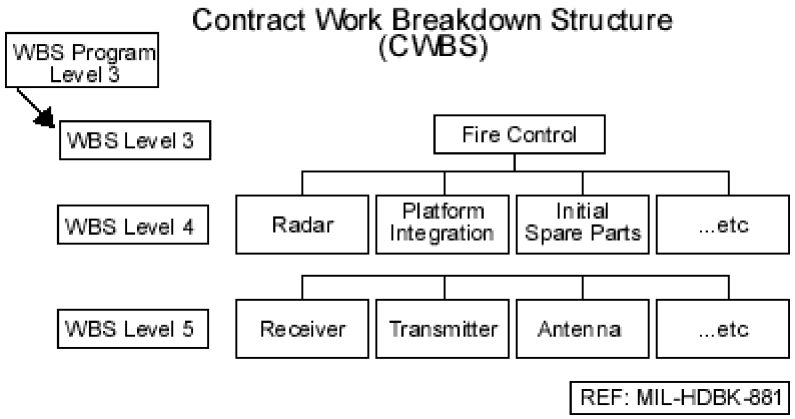
Contract WBS

A Contract WBS:

- Extends the Program WBS to a lower level in order to provide management and cost information to the Government.
- Includes all the elements for products (e.g., hardware, software, data, or services) that are the responsibility of the contractor.
- Must be consistent with the Program WBS.



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Military Handbook 881 and Contract WBS

Contractors may use Military Handbook 881 in extending the Program WBS for developing a

complete WBS. Military Handbook 881 shall be cited in solicitations and contracts as "for guidance only."

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Contract WBS: Contractor's Responsibility

Contractors may extend the work breakdown structure to whatever level they feel is necessary to manage the program. Contractors also use the Contract WBS to define work packages. Work packages are:

- Discrete portions of the project that can be charged to a single organization.
- Building blocks for program management and cost reporting.

Remember that a Contract WBS:

- Is prepared and maintained by each contractor working on different portions of the program.
- Includes the number of levels thought sufficient by the contractor to manage the program.
- Must be updated if changes are made to the Program WBS.

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Lesson 9: Financial Management: Cost Estimation

Budget Terms

Each of these terms has an official definition in budget execution.

TERM	DEFINITION
Budget Authority	"Budget Authority" is the authority granted by appropriations law to enter into obligations that will result in immediate or future outlays.
Commitment	A "commitment" is the administrative reservation of funds, usually by the local comptroller, in anticipation of a future obligation. A commitment is the response to a request for a spending action. It ensures that funds are available in the amount requested, in the correct fiscal year, and in the proper appropriation.
Obligation	An "obligation" is the legal reservation of funds to make a future payment of money. The obligation is incurred as soon as an order is placed, or a contract is awarded for the delivery of goods and performance of services.
Expenditure	An "expenditure" is a charge against available funds. It results from a voucher, claim, or other document approved by a competent authority. Expenditure represents the presentation of a check or electronic transfer of funds to the performer of the work.
Outlay	An "outlay" occurs when a vendor cashes the expenditure check and money flows from the Treasury to the vendor or supplier. With the advent of Electronic Funds Transfer (EFT), the time between an expenditure and outlay can be instantaneous.

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Scope of Life-Cycle Costs (LCC)

The Life-Cycle Cost is the total cost to the Government for a system over its entire life.

LCC includes all costs for:

- Research and development
- Investment (production and fielding)
- Facilities
- Operations
- Maintenance
- Environmental concerns
- Disposal

Life-Cycle Cost Estimates (LCCEs)

All military departments and defense agencies perform Life-Cycle Cost Estimates (LCCEs) for their acquisition process. An LCCE:

- Is a very comprehensive estimate.
- Tries to identify all the costs from program initiation through disposal of the system from the inventory.
- Can span decades.

Purposes of Life-Cycle Cost Estimates

LCCEs have two primary purposes:

- Serve as the cost input for decisions on whether or not to continue, modify, or terminate development, production, and fielding of a system.
- Provide the basis for budget requests to Congress.

Life-Cycle Costs

DOD 5000.4-M, Chapter 3, takes the total Life-Cycle Cost of an acquisition program and breaks it down in three ways:

1. **Appropriation Categories**

   Appropriation categories are types of funds used by the Government and consist of:

   - Research, Development, Test, and Evaluation (RDT&E)
   - Procurement
   - Operations and Maintenance (O&M)
   - Military Construction (MILCON)
   - Military Personnel (MILPERS)

2. **Work Breakdown Structure (WBS)**

   A Work Breakdown Structure (WBS) is an organized method to break down a project into logical subdivisions at lower and lower levels of detail.

   A Life-Cycle Cost Estimate uses the WBS to aggregate and show costs by system and subsystem.

3. **Life-Cycle Cost Categories**

   The life cycle cost categories consist of:

CATEGORY	DEFINITION
Research and Development (R&D)	R&D consists of all the costs associated with the research and development phases (i.e., Concept Exploration, Program Definition and Risk Reduction, and Engineering and Manufacturing Development).
Investment (Production and Fielding)	Investment costs include the cost of the investment phase (i.e., Production and Fielding of the system): the total cost of procuring the prime equipment, its related support equipment, facilities, initial spares, and fielding of the system.

Operations and Support (O&S)	O&S costs include the cost of the Operations and Support phase—all costs incurred in using the system including: personnel, fuel, maintenance (unit and depot), sustaining investments (replenishment spares), and training.
Disposal	Disposal costs include the cost to dispose of the system after its useful life. These costs are associated with disposing of the materiel system and include environmental and related costs. DOD 5000.2-R requires that these costs be estimated and included in the system's life cycle cost.

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Cost-Estimating Techniques

Each of the four major cost-estimating techniques has its strengths and weaknesses.

1. **Analogy:** Subjectively compares the new system with one or more existing similar systems for which there is accurate cost and technical data.

   Strengths
   - Quick
   - Inexpensive
   - Easy to change

   Weaknesses
   - Subjective
   - Not as precise

2. **Parametric:** Sometimes known as the statistical method, this technique:
   - Generates an estimate based on system performance or design characteristics.
   - Uses a database of elements from similar systems.
   - Differs from Analogy in that:
     - Uses multiple systems.
     - Makes statistical inferences about the cost estimating relationships (CER).

   Strengths
   - Uses cost estimating relationships
   - Easy to do "what-if drills"
   - Inexpensive

   Weaknesses
   - Moderately subjective
   - Precision only as good as the data base

3. **Engineering:** "Bottom-up" method of cost analysis that is the most detailed of all the techniques and the most costly to implement. Each WBS element must be costed to build the cost estimate for the entire program.

   Strengths
   - Very accurate in later stages of Engineering and Manufacturing Development (EMD)
   - Limited subjectivity

   Weaknesses
   - Very expensive
   - Very time-consuming
   - Difficult to do "what-if drills"

4. **Actual Costs:** Extrapolation from actual costs that were contracted for or actually incurred on that system during an earlier period.

Strengths	Weaknesses
• Little subjectivity • Very accurate	• Little applicability • Budget may already be submitted

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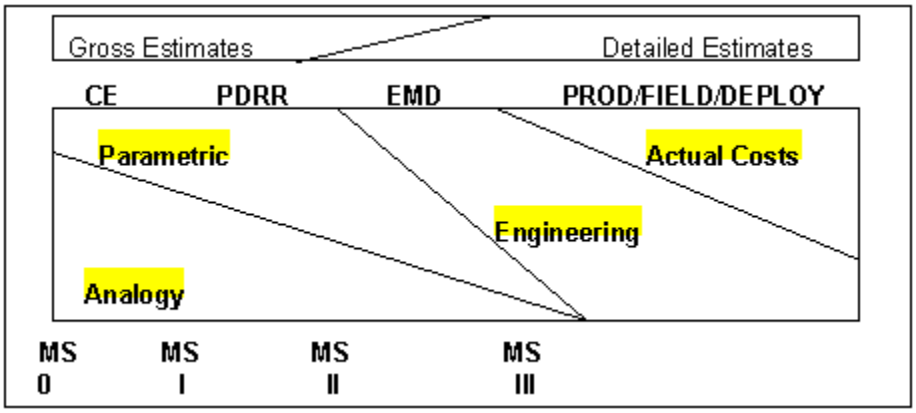
Estimating Technique and the Acquisition Life Cycle

The use of each technique is based on the information available to support it. The following figure is a summary of the usual application of each technique in the acquisition process.



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Cost Estimate Types

All programs will normally be required to have a cost estimate completed when they come to a milestone review. The type of estimate required and the organization that prepares the estimate varies depending primarily on the program's ACAT level.

The three types of cost estimates are:

- Program Office Estimate (POE)
- Component Cost Analysis (CCA)
- Independent Cost Estimate (ICE)

Program Office Estimate (POE)

DOD 5000.2-R requires the program office to prepare a life cycle cost estimate for all ACAT I and ACAT IA programs, which should cover all costs from program initiation through disposal.

This estimate is:

- Prepared in support of program initiation and for subsequent milestone reviews.
- Not required by regulation for programs other than ACAT I and ACAT IA, but the PM will probably be required to prepare a POE for other ACAT programs for all milestone reviews.

Component Cost Analysis (CCA)

Each of the Army, Navy, and Air Force Service headquarters has a cost analysis agency that prepares a separate and distinct cost estimate on programs.

This estimate:

- Is required for ACAT IA programs at milestones I and II.
- Is performed on the programs at the discretion of the Component Acquisition Executive (CAE).
- Serves as the independent cost estimate (ICE) for ACAT IC programs.

The Service cost analysis agency that prepares the CCA also reviews POE computations, methodologies, and assumptions.

The Component Acquisition Executive approves the Service cost position that is derived from the reconciliation between the CCA and the POE.

Independent Cost Estimate (ICE)

The OSD Cost Analysis Improvement Group (CAIG) is an organization outside the Service acquisition community chain. The CAIG prepares a separate and distinct cost estimate on ACAT ID programs, known as the Independent Cost Estimate.

This estimate is:

- Required by Title 10, U.S. Code for all ACAT I programs prior to MS II and III.
- Required by regulation for all ACAT I programs prior to MS I, II, and III.

Title 10, U.S. Code, Section 2434 prescribes that the Secretary of Defense may not approve a Major Defense Acquisition Program (MDAP) entering either the Engineering and Manufacturing Development (EMD) or the Production/Deployment phases unless "a manpower estimate and Independent Cost Estimate (ICE) of the program's life cycle cost is first submitted to the Secretary."

Cost Analysis Requirements Description (CARD)

In preparation for a milestone review the program office prepares the Cost Analysis Requirements Description for ACAT I and ACAT IA programs. The CARD document:

- Is used to develop the POE, CCA, and ICE.
- Describes the specifications of the program and assumptions the program office used in preparing the POE.
- Is provided to other groups that perform cost estimates on the program.
- Helps ensure all groups are costing out the same "program."

OSD Cost Analysis Improvement Group (CAIG)

In addition to preparing the ICE, the CAIG also:

- Advises the Defense Acquisition Board (DAB) on matters concerning the estimation, review, and presentation of cost analysis.
- Serves as the principle advisory body to the Secretary of Defense on matters relating to cost.
- Develops common cost-estimating procedures for DOD.

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Cost Estimate Review Process

The overall process of creating, reconciling, and approving a program cost estimate involves several key organizations. The following summarizes the participants and their roles.

PARTICIPANTS	ROLES
Program Office	The Program Office Estimate is prepared.
Component Cost Analysis Organization	The Component Cost Analysis is prepared (if required). • While each service prepares for a Milestone Review slightly differently, each generally follows a similar process. • The POE and the CCA are compared and differences are reconciled.
Service or Component Assistant Secretary for Financial Management	For programs approved at the service level (i.e., ACAT IC, ACAT IAC, and ACAT II and III programs), cost estimates are taken through the service's Assistant Secretary for Financial Management, and then to the appropriate Service Decision Panel for the milestone recommendation to the Component Acquisition Executive (CAE).
OSD Cost Analysis Improvement Group (CAIG)	For ACAT ID programs, the OSD Cost Analysis Improvement Group completes an Independent Cost Estimate. The ICE and service cost positions are reconciled between representatives from the CAIG and the service involved.
Overarching Integrated Product Team (OIPT)	Both the ICE and the service position are considered by the OIPT in preparing the program for Defense Acquisition Board evaluation.
Defense Acquisition Board (DAB)	The POE and the ICE are used as part of the milestone decision process.

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Lesson 10: Financial Management: Resource Allocation Process

Defense Appropriations

Appropriations have their basis in the Constitution. Article 1, Section 9, states that no money can be withdrawn from the U.S. Treasury except as a result of appropriations made by law.

An appropriation is the means of providing budget authority or funding for a program.

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DOD Appropriations Categories

Congress provides the DOD with five major appropriations categories of funds, often referred to as "colors of money." Each category is intended to fund specific items.

The five categories are:

- Research, Development, Test, and Evaluation (RDT&E)
- Procurement
- Operations and Maintenance (O&M)
- Military Personnel (MILPERS)
- Military Construction (MILCON)

Research, Development, Test, and Evaluation (RDT&E)

The RDT&E appropriations category funds the following types of activities:

- Development of equipment, material, or computer application software
- Developmental Test and Evaluation (DT&E)
- Initial Operational Test and Evaluation (IOT&E)
- Operational costs for R&D dedicated installations

Procurement

The Procurement appropriations category funds the following types of items and activities:

- Purchase of major end items and defense systems.
- Initial issue of spares for above items.
- All costs necessary to deliver a useful end item intended for operational use or inventory.

Shipbuilding and Conversion, Navy (SCN)

Part of the Procurement appropriations category is broken out separately because it has a longer "obligation" period than other procurement accounts. Shipbuilding and Conversion, Navy (SCN) is used to fund procurements and overhaul Naval ships.

Operations and Maintenance (O&M)

The O&M appropriations category funds the following types of items and activities:

- Day-to-day operations
- Headquarters operations
- Civilian salaries
- Travel
- Fuel
- Minor construction
- Training and education
- Expenses of operational military forces
- Base operations support
- Recruiting

Military Personnel (MILPERS)

The MILPERS appropriations category funds the following types of items:

- Pay and allowances of active duty and reserve military personnel
- Permanent Change of Station (PCS) moves
- Training in conjunction with PCS moves
- Subsistence
- Bonuses
- Retired pay accrual

Military Construction (MILCON)

The MILCON appropriations category funds the following types of items:

- Major military construction projects
- Construction of military schools
- Construction of facilities
- Construction of bases

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Obligation Periods

Each appropriation has a legal time limit, or obligation period, within which funds can be obligated (i.e., committed to a contract).

The table below shows the obligation period for each appropriations category.

Appropriations Category	Obligation Period
RDT&E	2 years
Procurement Shipbuilding and Conversion, Navy (SCN)	3 years (5 years)
O&M	1 year
MILPERS	1 year

MILPERS	1 year
MILCON	5 years

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Funding Policies

As a measure of fiscal discipline and control, Congress specifies funding policies or rules for each particular appropriations category. These policies specify how the DOD computes the budget request for each appropriations category in a given year. These funding policies are called annual, incremental, and full funding.

When forecasting financial requirements for an appropriation, the applicable funding policy must be known. The table below specifies the funding policy that applies to each appropriations category.

Appropriation	Funding Policy
RDT&E	Incremental
Procurement	Full
O&M	Annual
MILPERS	Annual
MILCON	Full

Annual Funding Policy

The annual funding policy governs MILPERS and O&M. The annual funding rule states:

> "Request the Budget Authority necessary to cover all expenses for goods and services for that fiscal year."

$K	FY96	FY97	FY98
Fuel	40	41	43
Spare Parts	15	17	18
Supplies	10	10	11
Maintenance	15	16	17
Training	5	5	5
	85	89	94

For FY96, an amount of $85K would be requested.

Annual Funding Policy Example

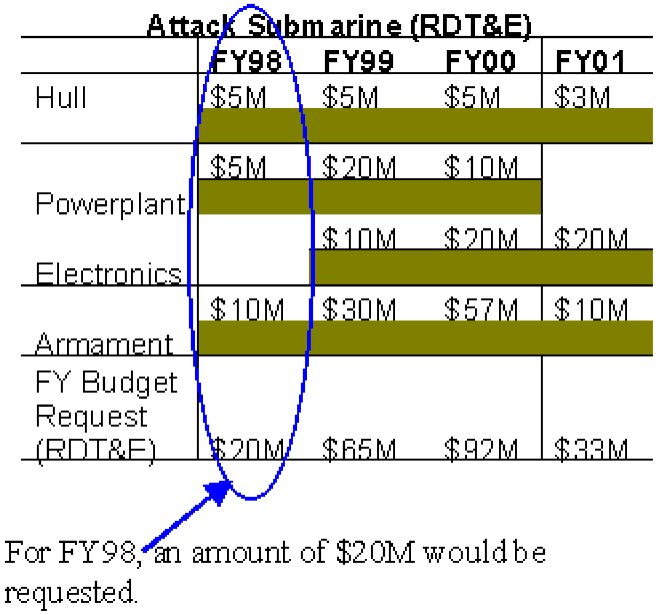
Incremental Funding Policy

The incremental funding policy governs the RDT&E appropriations category. The incremental funding rule states:

> "The annual increment for any RDT&E program element or project will be limited to the budget authority necessary to cover all costs expected to be incurred to support work to be performed during a 12-month period."

Incremental Funding Example

The table below represents the different tasks in the development of an attack submarine. It indicates work completion dates and the estimated costs of that work for each year. RDT&E funds are budgeted only for the work expected to be performed each fiscal year.



Full Funding Policy

The full funding policy governs the Procurement (including Shipbuilding and Conversion, Navy [SCN]) and Military Construction appropriations categories.

The full funding rules states:

> "Each year's appropriation request must contain the funds estimated to be required to cover the total cost to be incurred in completing delivery of a given quantity of usable end items."

For Procurement appropriations categories, deliveries must occur within a future 12-month period.

Full Funding—Key Concepts

Full funding policy has three key concepts:

- Usable End Items
- 12-Month Delivery Period
- Budget for Fiscal Year of Contract Award

Usable End Items

The program budget is required to have all funds necessary to cover a given quantity of usable end items. This means that:

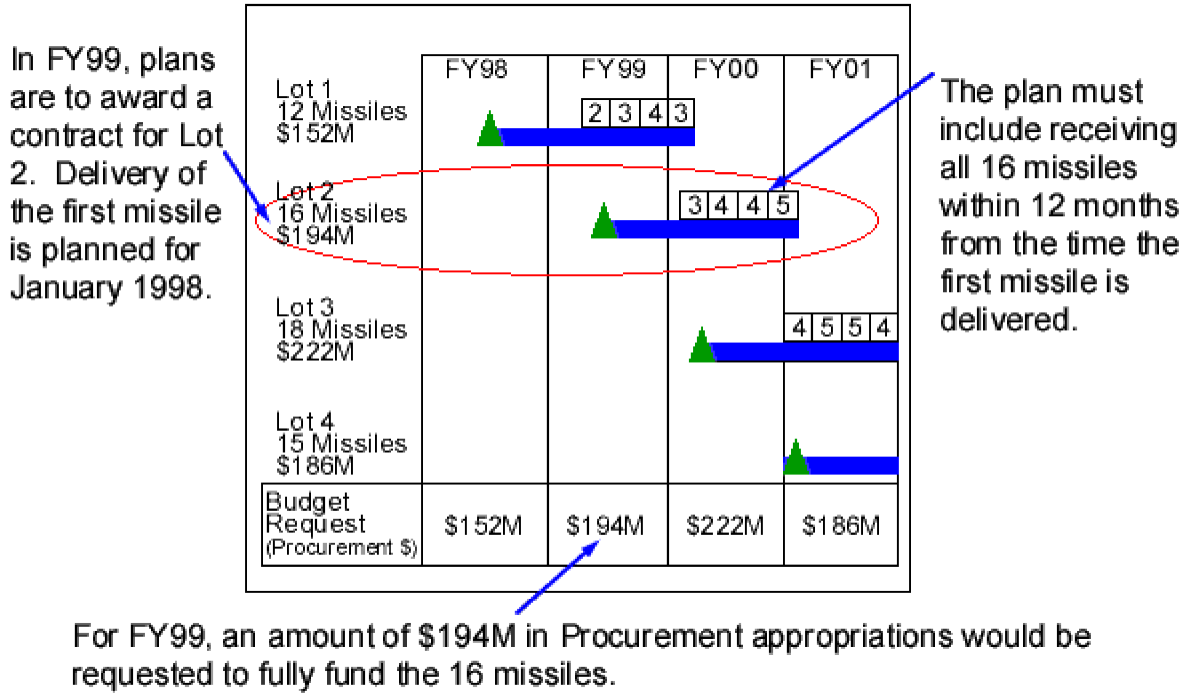
- Items must be bought as an "all-up" system and delivered as such.
- The DOD **cannot** budget for the hull one year, engines the next, electronics the next, and then plan on assembling all these parts into a ship in the fourth year.
- All items must be budgeted together as a Usable End item.

Funded Delivery Period

The time from delivery of the first unit in a lot to the delivery of the last unit in a lot must not exceed 12 months.

Budget for Fiscal Year of Contract Award

The funds must be budgeted in the fiscal year in which a contract award is anticipated. The following chart illustrates the full funding policy.



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What Is the Planning, Programming, and Budgeting System (PPBS)?

After the program has identified how much funding is needed for each appropriation category and year in the budget request, the next step is to get service/agency and eventually DOD approval to request those funds.

The DOD uses the PPBS to identify the fiscal needs of the services and decide how to allocate resources. It is an annual balancing act between requirements competing for limited funds.

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The Future Years Defense Program (FYDP)

The foundation of the PPBS is the Future Years Defense Program (FYDP). The FYDP is a computerized data base that summarizes the force structure, personnel strength, and financial resources of DOD. It is updated at selected times during the PPBS cycle.

The FYDP contains 11 years of data:

- Prior year
- Current year
- The two budget years
- Four outyears
- Three additional years of force structure only

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Future Years Defense Program (FYDP) Structure

The data contained in the FYDP are organized in three different ways:

- Major Force Programs (MFPs)
- DOD Appropriation Categories
- Components (Services and Agencies)

The primary purpose of the FYDP is to summarize the:

- Force structure,
- Personnel strength, and
- Financial resources of DOD throughout the PPBS process

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Major Force Programs (MFPs)

The FYDP organizes the data into 11 different MFPs that:

- Include all costs associated with a particular mission area (e.g., MFP3—Intelligence and Communications).
- May contain programs from different services and agencies, or from multiple appropriations.

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DOD Appropriation Categories

Appropriation categories are the major funding classes by which Congress provides funds for all Federal agencies, including the DOD.

The FYDP tracks the DOD funds by appropriation category to align the President's Federal Budget with the congressional appropriations. Each appropriation category may include funding for different services or MFPs.

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Components

The FYDP tracks funds for each of the three military services and other DOD agencies that request funding through the DOD PPBS process.

Each data set may contain funding from different appropriation categories and different MFPs.

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PPBS Phases

The PPBS process is divided into three phases:

- Planning—"How much defense is enough?"
- Programming—"How much defense can we afford?"
- Budgeting—"Are we executing efficiently?"

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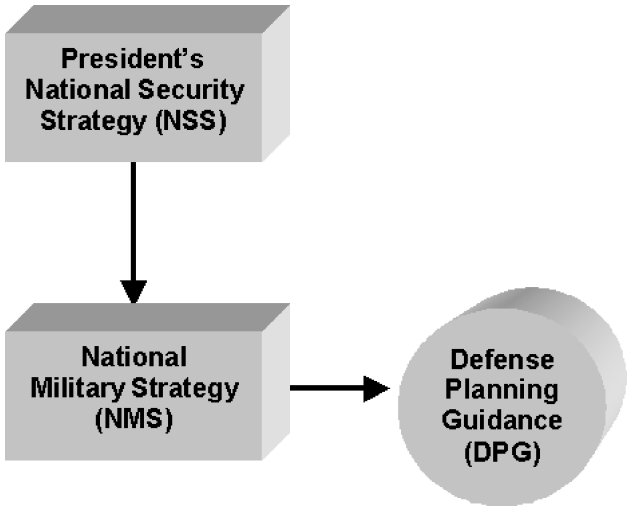
Planning Phase

The Planning Phase is controlled by the Under Secretary of Defense (Policy), and the purpose is to develop top-level policy guidance.

The primary product of this phase is the Defense Planning Guidance (DPG), which provides priorities and objectives for the service program requests. The following are key documents in the Planning

Phase.



Planning Phase—National Security Strategy (NSS)

The Planning Phase begins with the President's National Security Strategy (NSS). The NSS details the top-level political, economic, and security strategy for the United States.

Planning Phase—National Military Strategy (NMS)

The National Security Strategy provides input for the National Military Strategy. To produce the NMS, the Joint Chiefs of Staff (JCS) assess the evolution of the global threat, and changes in U.S. military strategy and policy. From this analysis, the JCS establishes military goals and objectives to meet the NSS.

Planning Phase—Defense Planning Guidance (DPG)

The Planning Phase culminates in the publication of the Defense Planning Guidance. The DPG provides a strategic framework for developing the Service and DOD Agency program requests. The DPG is the result of planning efforts by the Joint Staff, Office of the Secretary of Defense (OSD), and the services/agencies.

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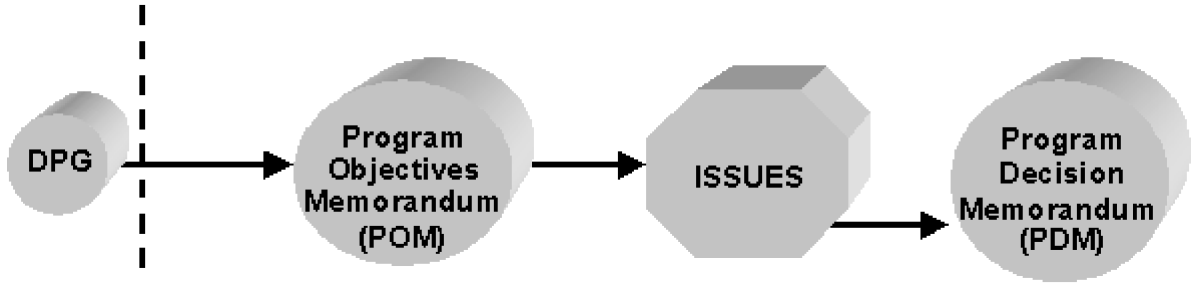
Programming Phase

During the Programming phase, each service and agency recommends to the OSD the resource and program requirements it needs to support the goals specified in the DPG.

The Director, Program Analysis and Evaluation (PA&E) manages this PPBS phase.

The primary products are the Program Objectives Memorandum (POM) and the Program Decision Memorandum (PDM).



Programming Phase—Program Objectives Memoranda (POMs)

- Each Program Office prepares a POM, based on program requirements.
- Each service and defense agency prepares a POM, documenting its fiscal requirements, based on input from the field and guidance from the DPG.

Programming Phase—POM Issues

After the services and agencies submit their POMs, the OSD examines and proposes alternatives to balance the limited funding across the DOD and still achieve DPG goals. At this point, programs are prioritized to determine which ones best meet DOD goals at an affordable level.

Programming Phase—Program Decision Memoranda (PDMs)

Changes to the service and agency POMs are documented in PDMs, which are issued by the Secretary of Defense. The PDMs approve the POMs, thus ending the Programming phase.

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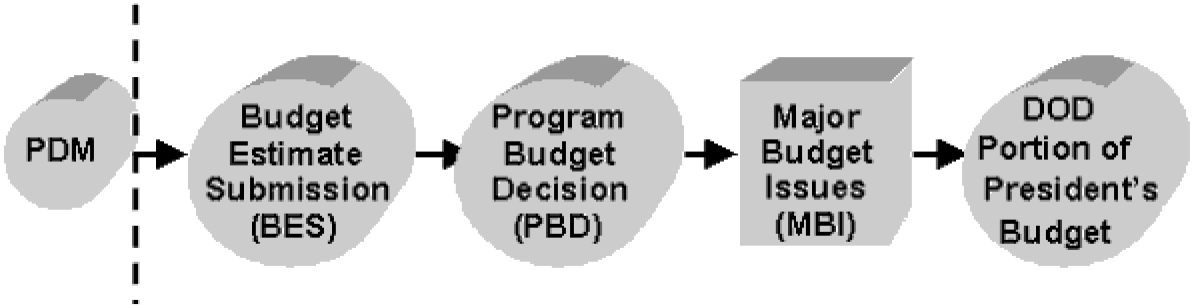
Budgeting Phase

The third phase of the PPBS process is the Budgeting Phase. This phase focuses on the effective use of funds and the balancing of limited funds.

The Under Secretary of Defense (Comptroller) is responsible for this phase.

Products of the Budgeting Phase are the Budget Estimate Submissions (BESs), Program Budget Decisions (PBDs), Major Budget Issues (MBIs), and the DOD portion of the President's budget.



Budgeting Phase—Budget Estimate Submissions (BESs)

The changes to the service POM, including those in the PDM, provide the basis for each service's and defense agency's Budget Estimate Submission. Each service and defense agency specifies fiscal requirements for the next budget cycle to the OSD Comptroller.

Budgeting Phase—Program Budget Decisions (PBDs)

- The OSD (Comptroller) reviews each program's input to the BES. The Comptroller verifies that each program will be able to use the funds requested.
- The OSD adjusts the programs' budgets by issuing draft Program Budget Decisions.
- Services and agencies are allowed to reclama the draft PBDs. The OSD reviews the reclama and makes final adjustments to the BESs. The decisions are issued as signed PBDs.

Budgeting Phase—Major Budget Issues (MBIs)

Any major, unresolved issues are identified as Major Budget Issues. The issues are discussed and the Secretary of Defense makes a decision, which is issued as a signed PBD.

Budgeting Phase—President's Budget

- Adjustments are incorporated into the President's Budget input.
- The DOD Budget is then sent to the Office of Management and Budget (OMB), which combines the DOD Budget with the rest of the Federal Budget.
- The OMB then sends the Federal Budget to the President for review. The President annually sends the Federal Budget to Congress on the first Monday in February.

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Congressional Review of President's Budget

After the President's Budget is submitted to Congress, three basic activities must be completed:

1. Budget Resolution
2. Authorization
3. Appropriation

Each activity has a specific objective and should be completed before the new fiscal year begins.

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Budget Resolutions

Budget Resolutions are passed by both Houses of Congress, but do not require the signature of the President. Resolutions set spending ceilings for each major appropriation.

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Authorization Bills

An Authorization Bill is an act of Congress that provides permission for a Federal program or activity to begin or continue from year to year. This type of bill sets staffing levels and system quantities, as well as limits on program funds. However, an Authorization Bill does not grant funding. Before becoming law, the Authorization Bill must be signed by the President.

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Appropriations Bills

An Appropriations Bill is an act of Congress that provides budget authority and permits Federal agencies to incur obligations and make payments from the U.S. Treasury. Appropriations do not represent cash actually set aside in the U.S. Treasury. Rather, appropriations represent limitations on amounts that agencies may obligate during a specific timeframe. Before funds can be spent, an Appropriations Bill must be signed by the President.

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Purpose of Congressional Committees

Each set of committees has a specific purpose and role in reviewing DOD budget requests.

Budget Resolutions	House and Senate Budget Committees
Authorization Bills	House National Security Committee and Senate Armed Services Committee
Appropriations Bills	House and Senate Appropriations Committees

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House and Senate Budget Committees

The House and Senate Budget Committees set overall budget ceilings for the various "Major Appropriations." These committees are responsible for drafting the "Concurrent Budget Resolution." This resolution:

- Provides program approval.
- Must be passed by both Houses of Congress.
- Establishes Federal budget ceilings.
- Does not require the President’s signature because it is not a law.
- Requires a 60 percent approval by both Houses of Congress if established ceilings are to be exceeded.

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House National Security Committee (HNSC) and Senate Armed Services Committee (SASC)

These two committees:

- Review the President’s Budget.
- Hold hearings on DOD appropriations.
- Draft the Defense Authorization Bill.

The Defense Authorization Bill must be passed by both Houses of Congress and signed by the President. This Bill also:

- Provides program approval.
- Specifies policies to be followed.
- Authorizes specific quantities of systems to be procured.
- Approves all new programs.

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House and Senate Appropriations Committees

The House and Senate Appropriations Committees:

- Review the President's Budget.
- Hold hearings.
- Draft various Appropriations Bills.

These bills must be passed by both Houses of Congress and signed by the President. After being signed, appropriations bills establish the Budget Authority. The Budget Authority permits Federal agencies to incur obligations and make expenditures from the U.S. Treasury.

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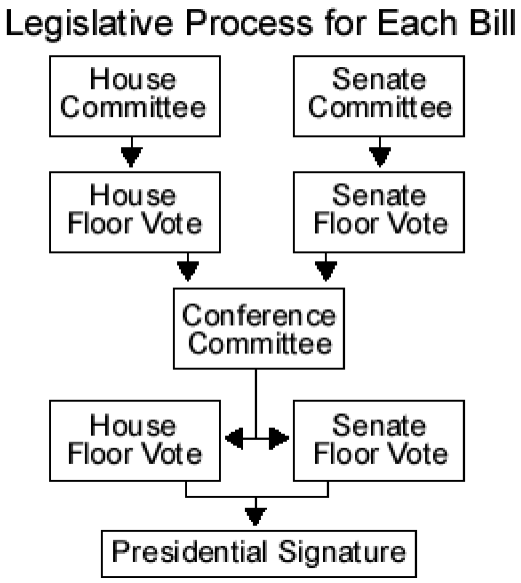
Legislative Process

The Authorization and Appropriations Bills each must follow several steps:

- Each committee drafts legislation.
- Each Chamber votes on its version.
- The Conference Committee crafts a compromise between the two versions of the bill.
- Each chamber votes on the new version.
- The President signs the bill.

At each step in the process, the funding requests may be changed, on the basis of the perceived needs of the country and the political process. The end result is a series of laws authorizing and providing budget authority for DOD activities.



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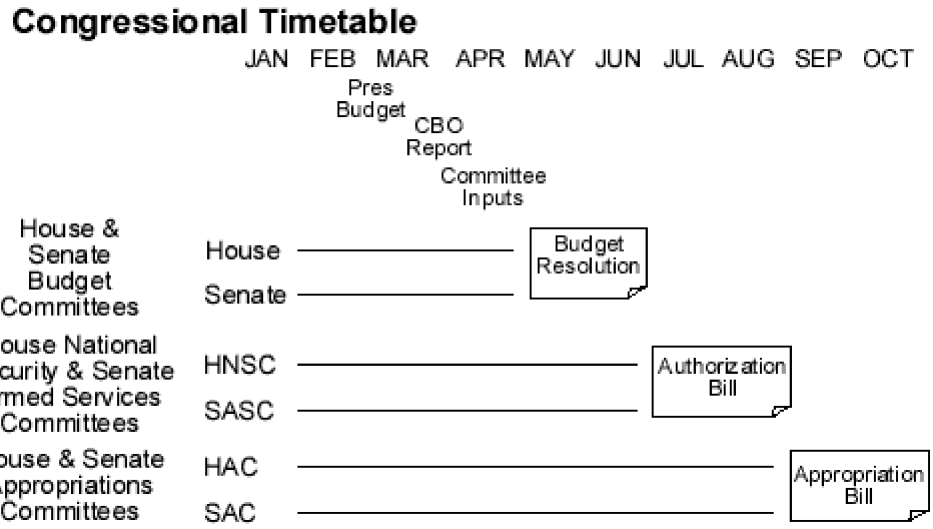
Congressional Timetable

Congress receives the President's Budget and passes it to the various committees.

These committees draft the Concurrent Budget Resolutions, the Authorization Bills, and the Appropriation Bills that must be passed by Congress.

These activities overlap. The graphic below shows "ideal" timeframes.



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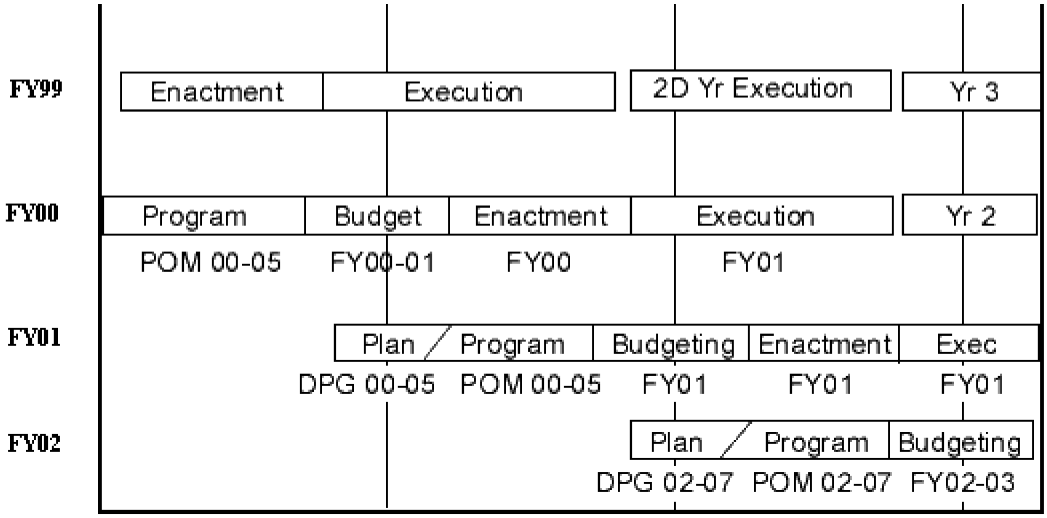
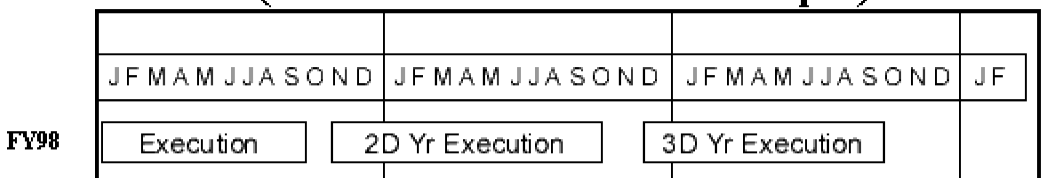
Annual Budget Overlap

At any given time during a calendar year (CY), activities involving different fiscal year (FY) budgets overlap. While one FY budget is being executed, the next fiscal year is being enacted, and the following fiscal year is undergoing a PPBS review. The chart below illustrates this overlap.



ANNUAL BUDGET OVERLAP
(Procurement Funds Example)



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DOD Budget Reviews

DOD programs and budgets are reviewed and often adjusted on the basis of documentation and other factors. These reviews involve:

- Defending the program before different groups on an ongoing basis. The successful defense of a budget requires a clear and logical understanding of the process.
- Achieving a balanced and yet sufficient budget.
- Meeting national security objectives while operating within a fiscally constrained environment.

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REVIEW RESOURCES

Lesson 11: Financial Management: Program/Budget Execution

Budget Allocation Process (Apportionment)

After Congress passes the DOD Appropriations Bill and the President signs it, then the Office of Management and Budget (OMB) distributes the Budget Authority to the DOD. This distribution is called Apportionment.

The funds can then be obligated for the programs and needs defined in the budget development process.

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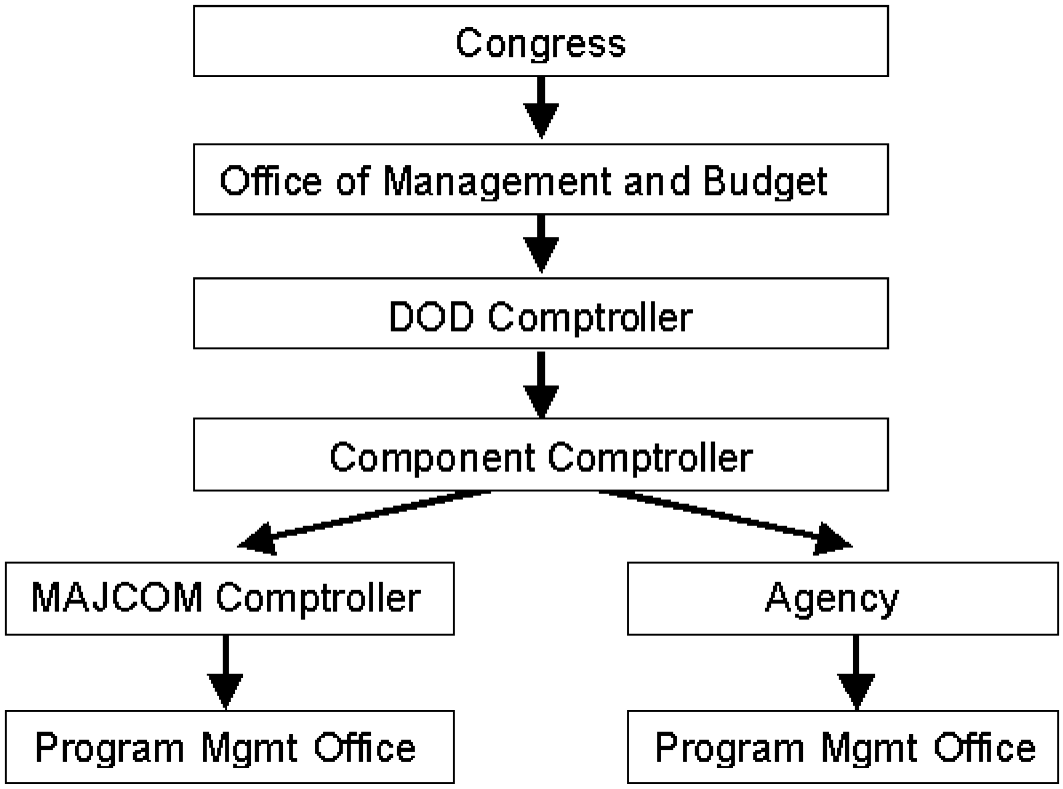
Flow of Funds

The Office of Management and Budget (OMB) apportions funds (Budget Authority) to the DOD Comptroller on a quarterly, annual, or other periodic basis, depending on the appropriation.

Following the apportionment of funds to the DOD Comptroller, the funds flow through a service or agency comptroller to a local comptroller in the product, buying, or operating command.



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Withholding of Funds ("Taxes")

As the funds flow through the DOD service comptrollers, and major command or local comptrollers, a small percentage of funds may be withheld for contingency purposes. These funds are unofficially referred to as "taxes" or "withholds." Taxes and withholds give the services the flexibility to meet minor contingencies.

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Apportionment Documentation

The Apportionment process can take several days. A signed document accompanies and carries out the actual movement of funds. The program office cannot obligate funds until the authority (i.e., paperwork) reaches the comptroller for the program office.

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Expiration of Funds

Each appropriation has a legal time limit, or "life," within which funds can be obligated.

The following table shows the "life" for each appropriation.

Appropriation Categories	Obligation Period
Research, Development, Test, and Evaluation (RDT&E)	2 years
Procurement (Shipbuilding and Conversion, Navy (SCN))	3 years (5 years)
Operations and Maintenance (O&M)	1 year
Military Personnel (MILPERS)	1 year
Military Construction (MILCON)	5 years

Research, Development, Test, & Evaluation (RDT&E)

The RDT&E appropriation category funds the following types of activities:

- Development of equipment, material, or computer application software
- Development Test and Evaluation (DT&E)
- Initial Operational Test and Evaluation (IOT&E)
- Operational costs for R&D dedicated installations

Procurement

The Procurement appropriation category funds the following types of items and activities:

- Purchase of major end items and defense systems.
- Initial issue of spares for above items.
- All costs necessary to deliver a useful end item intended for operational use or inventory.

Shipbuilding and Conversion, Navy (SCN)

Part of the Procurement appropriation category is broken out separately because it has a longer "obligation" period than other procurement accounts. SCN is used to fund procurement and overhaul Naval ships.

Operations and Maintenance (O&M)

The O&M appropriation category funds the following types of items and activities:

- Day-to-day operations
- Headquarters operations
- Civilian salaries
- Travel
- Fuel
- Minor construction
- Training and education
- Expenses of operational military forces
- Base operations support
- Recruiting

Military Personnel (MILPERS)

The MILPERS appropriation category funds the following types of items:

- Pay and allowances of active duty and reserve military personnel
- Permanent Change of Station (PCS) moves
- Training in conjunction with PCS moves
- Subsistence
- Bonuses
- Retired pay accrual

Military Construction (MILCON)

The MILCON apprpriation category funds the following types of items:

- Major military construction projects
- Construction of military schools
- Construction of facilities
- Construction of bases

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Expired Funds

After the funds have passed their obligation period (e.g., RDT&E is 2 years), they go into the "Expired Account" and cannot be used for new obligations. Funds are canceled 5 years after the end of the

obligation period.

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Obligation

An "obligation" is the legal reservation of funds to make a future payment of money. The obligation is incurred as soon as an order is placed, or a contract is awarded for the delivery of goods and/or performance of services.

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Outlay

An "outlay" occurs when the vendor cashes the expenditure check and money flows from the Treasury to the vendor or supplier. With the advent of Electronic Funds Transfer (EFT) the time between expenditure and outlay can be momentary.

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"Expired Funds"

- Funds remain in the "Expired Account" for 5 years after the obligation period ends.
- Funds in the "expired account" may be used to make expenditures on existing obligations and adjustments to obligations.
- While in the "expired account," funds retain all their fiscal identity (i.e., appropriation, fiscal year, and amount).

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Cancellation of Funds

After the 5-year "Expired" period has passed, the funds are canceled and can no longer be used. Any remaining outlay requirements after funds have been cancelled must be paid for using current year funds.

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Misappropriation Act

Title 31, U.S. Code, Section 1301, known as the Misappropriation Act, requires that funds appropriated by Congress be used only for the programs and purposes for which the appropriation is made.

For example, an agency cannot use RDT&E funds to purchase major weapons systems (aircraft, missiles, tanks, etc.).

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Anti-Deficiency Act

Title 31, U.S. Code, Sections 1314 and 1517, known as the Anti-Deficiency Act:

- Prohibits an obligation in excess of the appropriated amount or amount permitted by agency regulations.
- Forbids contract or obligation in advance of appropriations.
- Requires agency regulations to monitor and fix responsibility for violations of the act.

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Need for Reprogramming Authority

Congress recognizes the need for some flexibility in budget execution. Accordingly, Congress has provided the DOD with a method to make limited changes in its appropriated funding.

Reprogramming permits the use of funds for purposes other than those originally intended by Congress. Depending on the circumstances, approval for reprogramming may be internal to the DOD or may involve Congress.

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Congressional Prior Approval Reprogramming

Congressional Prior Approval Reprogramming is required for actions involving:

- Congressional Special Interest Items
- Major system procurement quantity increases
- General Transfer Authority

Congressional Prior Approval Reprogramming requires:

- Approval by the Secretary of Defense, and
- Approval by the key Congressional committees:
  - House National Security Committee (HNSC)
  - Senate Armed Services Committee (SASC)
  - House Appropriations Committee (HAC)
  - Senate Appropriations Committee (SAC)

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Congressional Notification Reprogramming

Congressional Notification Reprogramming is required for:

- Actions that exceed the dollar threshold limits for below threshold reprogramming.
- Starting new programs that have significant follow-on costs.

Congressional Notification Reprogramming requires:

- Approval by the Secretary of Defense.
- Written approval by SASC and SAC.
- That the House must act within 15 days or approval is assumed.

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Internal Reprogramming

Internal Reprogramming actions:

- Do not involve a change in the purpose or amounts approved by Congress.
- Must be approved by the DOD Comptroller.
- Apply mainly to administrative realignment of funds.

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Below Threshold Reprogramming

Most reprogramming actions that involve defense systems are accomplished using Below Threshold Reprogramming.

Below Threshold Reprogramming:

- Allows the transfer of funds among programs within an appropriation category, but it is subject to certain rules and limitations.
- Is controlled and approved by local or service/defense agency comptrollers.
- Does not require Congressional involvement.

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Below Threshold Reprogramming—Dollar Thresholds

Congress placed strict dollar limits, or thresholds, on when DOD may use Below Threshold Reprogramming.

- These thresholds limit the amount of funding that may be transferred into or out of affected accounts.
- These thresholds vary by appropriations category.

This table summarizes the limitations on Below Threshold Reprogramming into and out of a program.

Appropriations	Reprogramming	
	Into or Out of	
RDT&E	+$4M	Greater of -$4M or -20%
Procurement	+$10M	Greater of -$10M or -20%
O&M	+$15M	-$15M
MILPERS	+$10M	No Restriction Specified

MILCON	Lesser of +$2M or 25%	No Restriction Specified

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Below Threshold Reprogramming Limitations

While Below Threshold Reprogramming allows limited transfer of funds among programs, Below Threshold Reprogramming **cannot** be used to:

- Transfer funds that require Congressional involvement (e.g., Congressional Prior Approval).
- Change the appropriation category of any funds (e.g., Change RDT&E funds into O&M funds.)
- Change the fiscal year (FY) of any funds (e.g., Change FY 98 funds into FY 97 funds).

Below Threshold Reprogramming (BTR): Example

The Army Comptroller may reprogram FY 97 Procurement funds from the Commanche Program into the Apache FY 97 Procurement account.

Those funds may **not** be reprogrammed into Apache's RDT&E account using Below Threshold Reprogramming. Because such a transfer would involve changing appropriation categories, Congressional involvement would be required.

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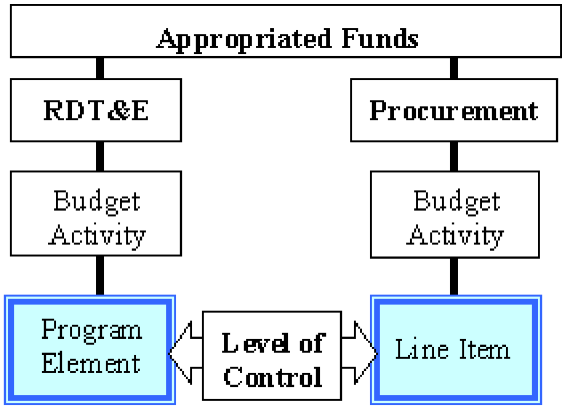
Below Threshold Reprogramming—Level of Control

The reprogramming thresholds are applied at the "level of control" of that appropriation category. The "level of control" for RDT&E is the Program Element. The "level of control" for Procurement is the Line Item.

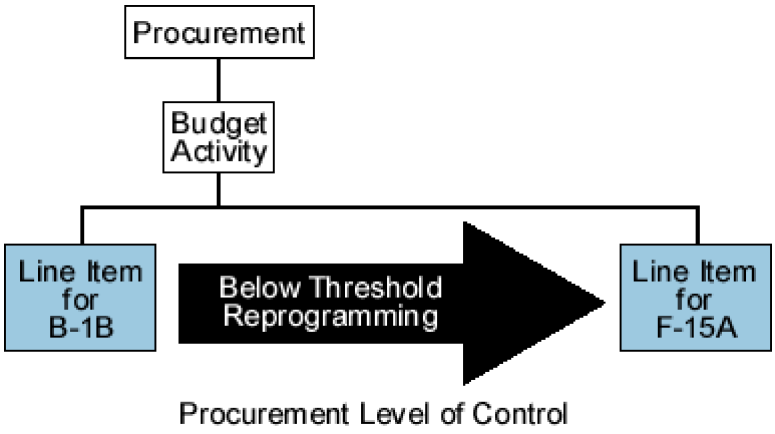


Shown below is a summary of the thresholds and levels of control for the key acquisition-related appropriations.

Appropriations	Reprogramming Into or Out of		Controlled at
RDT&E	+$4M	Greater of -$4M or -20%	Program Element
Procurement	+$10M	Greater of -$10M or -20%	Line Item
O&M	+$15M	-$15M	Budget Activity
MILPERS	+$10M	No Restriction Specified	Budget Activity
MILCON	Lesser of +$2M or 25%	No Restriction Specified	Project

Below Threshold Reprogramming—Level of Control: Example

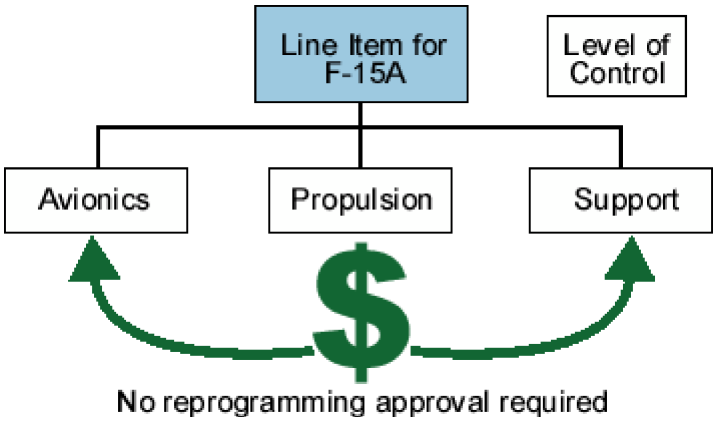
The Air Force Comptroller may reprogram up to $10 million into the F-15A Line Item from the B-1B Line Item.



Below Threshold Reprogramming—Below Level of Control

Realigning funds between activities that are below the level of control for that appropriation category does not require a reprogramming action.

This type of funds transfer can be approved by the Program Manager.



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Lesson 12: Contract Management: Planning for Solicitation

Definition of a Contract

A contract:

- Establishes a legal relationship between two parties;
- Defines the rights and responsibilities of each party;
- Allows for changes within the terms and conditions of the legal relationship; and
- Requires five essential elements to be binding.

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Elements of a Contract

Essential Elements	Features
Offer	Must: 1. Express intent 2. Be communicated 3. Have complete terms (price, quantity, quality, and delivery) 4. Be clear and unambiguous
Acceptance	Must be: 1. Timely 2. Clear and unequivocal 3. A mirror image of the offer
Consideration	Types include: 1. An act 2. Forbearance to act 3. Sufficiency and adequacy
Legal and Binding	Objective or purpose needs to be legal to be enforced in court.
Competent Parties	Both parties must be legally competent for a contract to be binding.

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The Federal Acquisition Regulations System

The Federal Acquisition Regulations System establishes the policies and procedures for acquisition by all executive agencies. It consists of the following:

- Federal Acquisition Regulations (FAR)
- The DOD FAR Supplement
- Agency supplements and acquisition regulations

The Contracting Officer uses the FAR to carry out the contracting process.

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The Contracting Officer

The Contracting Officer (CO) has the authority to:

- Enter into, administer, and/or terminate contracts, and
- Make related determinations and findings.

A CO's authority is given in writing on a Certificate of Appointment (SF 1402), commonly known as a warrant. The three types of Contracting Officers are:

Contracting Officer	Responsibilities
Procuring Contracting Officer (PCO)	The Procuring Contracting Officer: 1. Handles the procurement from the pre-solicitation phase through to contract award (including contract signing on the Government's behalf). 2. Has overall responsibility for the contract until it is completed and closed out.
Administrative Contracting Officer (ACO)	The Administrative Contracting Officer performs contract administration functions as assigned by the PCO. FAR 42.302(a) lists 69 functions normally performed by the ACO.
Termination Contracting Officer (TCO)	The Termination Contracting Officer is responsible for negotiating any settlement with the contractor after the Procuring Contracting Officer issues a notice of termination.

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Roles of the Program Manager and the Contracting Officer

The Program Manager (PM) has the overall responsibility for bringing the program in on time and within budget. The CO is the business advisor to the PM and is responsible for ensuring that all acquisition laws and regulations are followed.

Following is a comparison of the roles assigned to the PM and CO.

	Program Manager	Contracting Officer
Authority	Charter (Army & Navy) Program Management Directive (AF)	Warrant
Responsibility	Entire program	Contract
Background/Training	Technical	Business
Guiding Directives	DOD 5000 series	FAR
Organization	Program office (IPT)	Matrix (IPT)

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Competition Requirements

The competition requirements ensured by the Competition in Contracting Act include:

Competition Requirements	Description
Requirement for full and open competition	Full and open competition means all responsible sources are permitted to compete (FAR 6.003). The CO decides how full and open competition will be achieved.
Allowance for full and open competition after exclusion of sources	Excluding sources may be done for: 1. Establishing or maintaining alternate sources. Key is that the Government has more than one source for providing supplies or services whenever possible. 2. Set-asides for small business concerns, designed to promote the participation of small business concerns in defense contracting. 3. Section 8(a) program, designed to promote the participation of eligible, small disadvantaged business concerns in defense contracting.
Provision for seven exceptions to full and open competition	Seven exceptions to full and open competition include: 1. Only one responsible source will satisfy agency requirements. 2. Unusual and compelling urgency. 3. Industrial mobilization. 4. International agreement. 5. Authorized or required by statute. 6. National security. 7. Public interest.
Requirement for approval of exceptions to full and open competition	Approval of an exception to full and open competition is accomplished by the execution of a Justification and Approval (J&A) or a Determination and Finding (D&F) as required by FAR Subpart 6.3.

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Determination of Requirements

For a requirement to initiate the contracting process:

- A need must be identified,
- A non-materiel solution must not be available, and
- Approval must be given to pursue a materiel solution.

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The Requirements Package

The requirements package may contain the following:

- Management reviews and approvals.
- Certification of funds availability.
- Description of the requirements.
- Specifications (performance or detail).
    - Statement of Work (SOW)/Statement of Objective (SOO). (The SOO establishes a broad description of the Government's required performance objectives.)
    - Purchase descriptions.
    - Contract data requirements.
- Any special packaging and marking requirements.
- Inspection and acceptance requirements.
- Delivery or performance requirements.
- Any special contract administration requirements.
- Any special provisions or clauses.
- Recommended evaluation factors for contract award.
- Evaluation criteria for the evaluation factors.
- Recommended potential sources and results of market research.
- Input for approval of other than full and open competition, if needed.
- Acquisition Plan, if required.

The requirements package is put together by the Program Manager's Integrated Product Team (IPT) and delivered to the Contracting Officer.

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Methods of Contracting

The two primary methods of contracting are:

- Sealed bidding
- Contracting by negotiation

Sealed Bidding is used if:

- Time permits,
- Award is based on price and other price-related factors,
- Discussions are not necessary, and
- There is a reasonable expectation of competition (more than one sealed bid).

Any contract awarded without using sealed bidding is a **negotiated contract**. Types of negotiated contracts include:

- Sole source, which is a contract entered into, or proposed, after soliciting and negotiating with only one source.
- Competitive, in which more than one contractor is sought to solicit an offer, with the winner being selected on the basis of criteria established by the Government.

The following table summarizes the differences between sealed bidding and negotiated contracts.

Sealed bidding	**Negotiated**
Well-defined requirements	Less well-defined requirements
Adequate competition required	Competitive or sole source
Uses an Invitation for Bid (IFB) solicitation	Uses a Request for Proposal (RFP) solicitation
Award based on price and price-related factors	Award based on evaluation criteria
No discussions allowed	Discussions/negotiations usually required

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Types of Contracts

The two broad categories of contracts are:

- Fixed-price
- Cost-reimbursement

Other contract types combine features of these two categories. The following table compares fixed-price and cost-reimbursed contracts.

Fixed-price contracts	**Cost-reimbursed contracts**
Low risk to the Government	Higher risk to the Government
Well-defined requirements	Less well-defined requirements
Guaranteed delivery by the contractor	Contractor’s best effort
Payment after delivery or performance	Payment as costs are incurred
Profit based on efficient performance and cost control	Fee or formula to compensate the contractor beyond cost
Use of either an IFB or RFP	Use of an RFP

Review the comparison of the general contract types:

	Fixed-Price	**Cost-Reimbursement**
What is promised?	Acceptable goods and services	Best efforts
When is payment?	After delivery (progress payment possible)	As costs are incurred
Cost risk to: Contractor Government	 High Low	 Low High

Other contract types include indefinite delivery, time-and-materials, and letter. The following table describes these contracts.

This type of contract …	**Provides for …**	**And may be used when …**
Indefinite Delivery: Definite Quantity	Delivery of a definite quantity of specific supplies or services for a fixed period, with deliveries or performance to be scheduled at designated locations upon order.	1. A definite quantity of supplies or services will be required during the contract period. 2. The supplies or services are regularly available or will be available after a short lead time.
Indefinite Delivery: Indefinite Quantity	An indefinite quantity, within stated limits, of supplies or services to be furnished during a fixed period, with deliveries or performance to be scheduled by placing orders with the contractor.	Exact quantity of supplies or services is unknown.
Indefinite Delivery-Requirements	Filling all actual purchase requirements of designated Government activities for supplies or services during a specified contract period, with deliveries or performance to be scheduled by placing orders with the contractor.	Acquiring any supplies or services when the Government anticipates recurring requirements but cannot predetermine the precise quantities of supplies or services that designated Government activities will need during a definite period.
Time-and-Materials	Acquiring supplies and services on the basis of direct labor hours and materials at cost. A labor-hour contract is a variation differing only in that materials are not supplied by the contractor.	It is not possible at the time of placing the contract to estimate accurately the extent and duration of work or to anticipate cost with any reasonable degree of confidence.
Letter	A written preliminary contractual instrument containing a price ceiling that authorizes the contractor to begin immediately manufacturing supplies or performing services.	1. The Government's best interests demand that the contractor be given a binding commitment so that work can begin immediately. 2. Negotiating a definitive contract is not possible in sufficient time to meet the requirements.

Indefinite delivery contracts permit the Government to maintain only a minimum stock level by using direct shipments for the contractor with flexible delivery schedules. Indefinite Quantity/Indefinite Delivery and Requirements contracts (also known as delivery-order or task-order contracts) also permit flexibility in quantity purchased, minimizing the Government's obligation under the contract.

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Lesson 13: Contract Management: Solicitation, Evaluation, and Award

Method of Solicitation

The first step in solicitation and award is the notification to industry that a contracting need exists and the identification of the parameters of that need. Prior to this formal solicitation, the needs identified in the requirements package are synopsized in the Commerce Business Daily or other electronic means.

The solicitation communicates the requirement to industry. The method of contracting determines the method of solicitation:

Contracting Method	Solicitation Method	Term for Contractor Response
Sealed Bidding	Invitation for Bid (IFB)	Bid
Negotiation	Request for Proposal (RFP)	Proposal

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Uniform Contract Format (UCF)

Both IFB and RFP use the Uniform Contract Format (UCF). The UCF is a standardized format for preparing solicitations. It includes a table of contents for the solicitation and 13 sections (A through M) in 4 parts (I through IV).

The Uniform Contract Format for a Request for Proposal

Part I — The Schedules

Section A	Solicitation/contract form
Section B	Supplies or services and prices/costs
Section C	Description/specifications/work statement
Section D	Packaging and marking
Section E	Inspection and acceptance
Section F	Deliveries or performance
Section G	Contract administration data
Section H	Special contract requirements

Part II — Contract Clauses

Section I	Contract clauses

Part III — List of Documents, Exhibits, and Other Attachments

Section J	List of attachments

Part IV — Representations and Instructions

Section K	Representations, certifications, and other statements of offerors or respondents
Section L	Instructions, conditions, and notices to offerors or respondents
Section M	Evaluation factors for award

Critical sections include the following:

Critical Section	Contents	Description
Section B	Supplies or Services Prices/Costs	Brief descriptions of required supplies or services, including: 1. Quantities 2. National Stock Numbers (if applicable) 3. Part Numbers (if applicable) Each item in this section is identified by a Contract Line Item Number (CLIN).
Section C	Description/Specifications/ Work Statement/SOO/ PBSW	Descriptions, specifications, or additional information to identify additional Government requirements. Section C normally contains a Statement of Work (SOW), which: 1. Outlines the tasks for the contractor to perform. 2. Identifies applicable standards (Government and commercial). 3. Tells the contractor *what* to do, not *how* to do it. 4. Defines the scope of the work to be performed. The SOW should outline only the requirements that are needed. The more data the contractor must prepare, the more it costs the Government. Also, any specifications/standards should be tailored to fit the requirement. 5. Must be clear, concise, and consistent. If ambiguities exist in description or specifications, the court rules against the Government. Things to be aware in the Statement of Work include: • If ambiguities exist in the description or specifications, the court rules against the writer (Government). • The more data the contractor must prepare, the greater the cost, so order only what is needed. • If Federal/military specifications/standards must be used, tailor them to fit the requirements. Tailoring Federal/military

		specifications/standards is important to ensure that unnecessary work (which increases the cost of the contract) is not performed. Many of the specifications/standards require actions (e.g., numerous inspections, generation of reports) that may not be necessary for your requirements. • An incomplete tasking may leave a product unfinished, requiring additional work and, of course, additional funding. • Do not dictate how the work will be performed. If you do, and the product does not conform to the specifications, the contractor may not be liable for reperformance—the Government will be.
Section J	List of Attachments	Provides for each attached exhibit or other document: 1. Title 2. Date 3. Number of Pages A DD Form 1423, Contract Data Requirements List (CDRL) is often included.
Section L	Instructions, Conditions, and Notices to Offerors or Respondents	Includes solicitation provisions and other information and instructions not required elsewhere in the solicitation to guide offerors in preparing proposals. Information and instructions might include: 1. When and where to submit proposals. 2. How to submit proposals (paper, electronic). 3. Page limitations and type size. 4. Organization (format) of the proposal. 5. Past performance information. 6. Required cost or pricing data.
Section M	Evaluation Factors for Awards	Identifies all significant evaluation proposal factors and states the relative importance of each. Some evaluation factors include: 1. Price or cost. 2. Past performance. 3. Technical excellence. 4. Management capability. 5. Personnel qualifications. 6. Prior experience. 7. Schedule compliance.

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Evaluation of Proposals and Source Selection

The steps for evaluation and selection of a source for contract award are:

- Compare each proposal to the RFP.
- Compare the proposals to each other.
- Select the source for contract award.
- Determine if the price is fair and reasonable.

In the formal source selection process, a contract moves from the Contracting Officer (CO) to the Source Selection Evaluation Board (SSEB) to the Source Selection Advisory Council (SSAC) to the Source Selection Authority (SSA) and back to the CO. Key players in the source selection process are described in the following table.

Key Player	Responsibilities
Contracting Officer (CO)	1. Ensuring that the source selection process complies with procurement laws and regulations. 2. Providing the proposals to the SSEB for evaluation. 3. Reviewing the proposals to ensure the offerors. complied with all the requirements of the solicitation. 4. Communicating with offerors.
Source Selection Evaluation Board (SSEB)	1. Evaluating proposals against the requirements in the RFP. 2. Identifying weaknesses/significant weaknesses. 3. Identifying any deficiency. 4. Establishing the competitive range for the purpose of conducting discussion, based on SSEB evaluation.
Source Selection Advisory Council (SSAC)	1. When requested, performing a comparative analysis of the SSEB's evaluation of each proposal. 2. Forwarding a recommendation to the SSA.
Source Selection Authority (SSA)	1. Overseeing the process and ensuring its integrity. 2. Selecting the source or sources whose proposal is the best value for the Government. 3. Ensuring that qualified personnel are appointed to the SSEB and the SSAC.

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Fair and Reasonable Price Determination

The CO determines if an offeror's price is fair and reasonable by using one of the following techniques:

- Price Analysis
- Cost Analysis
- Technical Analysis
- Field Pricing Support

Analysis	Definition	Techniques
Price Analysis	Price analysis is the process of examining and evaluating a proposed price without evaluating its separate cost elements and proposed profit.	Price analysis techniques include: • Comparison of proposed prices received in response to the solicitation. • Comparison of prior proposed prices with current proposed prices for same or similar items. • Application of rough yardsticks (e.g., $/ton). • Comparison with competitive published price lists. • Comparison of proposed prices with independent Government cost estimates. • Comparison of proposed prices with prices obtained through market research.
Cost Analysis	Cost analysis is the process of reviewing and evaluating the separate cost elements and proposed profit of an offeror's or contractor's cost or pricing data or other cost or pricing information.	Cost analysis techniques include: • Applying judgmental factors in projecting from the data to the estimated costs to determine if the proposed costs represent what the cost of the contract should be. • Examining all elements of cost, such as materials, labor, overheads, and profit. Analysis usually requires the submission of cost or pricing data by the offeror, which must be requested specifically in the solicitation. When cost or pricing data are required, the CO should generally request a technical analysis of proposals to review the validity of the technical information provided by the offerors.

Cost analysis is more time-consuming than price analysis, and might increase the contract price.

Cost or pricing data must be specifically required by the Government in the solicitation. Cost or pricing data shall be obtained only if the CO concludes that one of the exceptions on the "Prohibitions on obtaining cost or pricing data" applies (FAR 15.403-1).

When cost or pricing data are required, the technical analysis of proposals by the appropriate technical personnel is generally requested by the CO. The purpose of this analysis is to review the validity of the technical information provided by the offeror.

Field pricing support may be provided by local DOD activities, to include:

- Accountants
- Auditors
- Price/cost analysts
- Negotiators
- Engineers
- Small and disadvantaged business utilization specialists
- Production specialists

The Defense Contract Management Command (DCMC) and the Defense Contract Audit Agency

(DCAA) can provide national and international assistance with field pricing support.

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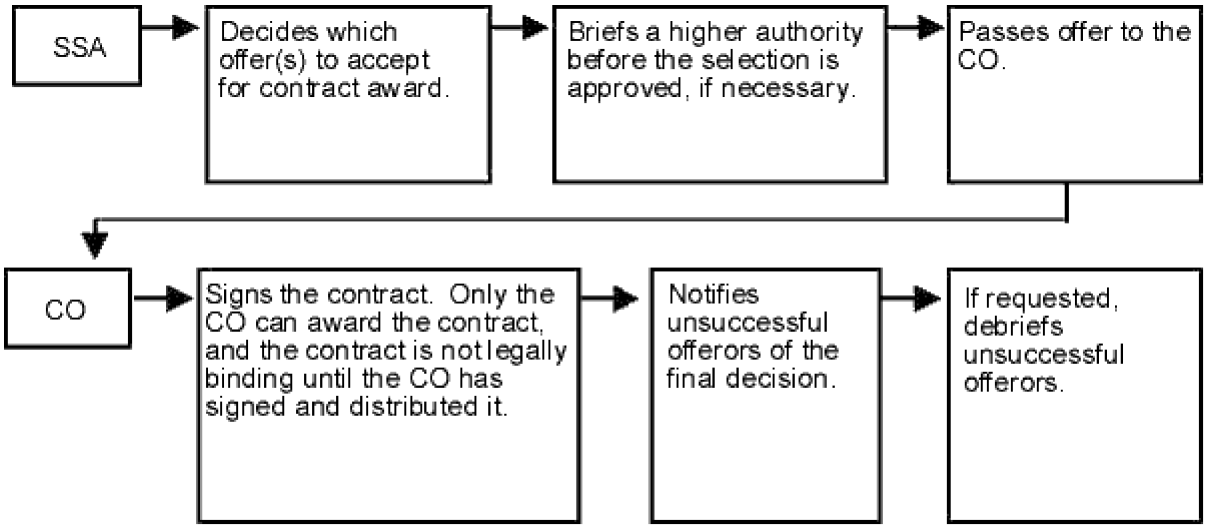
Contract Award

Following are the roles of the SSA and CO in contract award:



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Lesson 14: Contract Management: Post-Award

Agencies Performing Post-Award Functions

Three DOD agencies perform critical contract administration functions in systems contracting. They are:

Agency	Responsibilities
Defense Contract Audit Agency (DCAA)	The DCAA is a DOD organization that has the responsibility of performing contract audit services for the Department. The DCAA provides accounting and financial advisory services (before and after award) in connection with negotiating, administering, and closing out contracts and subcontracts.
Defense Finance and Accounting Service (DFAS)	The DFAS is responsible for the payment on all DOD contracts, with 5 payment centers and 20 smaller operating locations (OPLOCs) throughout the United States. The DFAS must make timely payments to contracts authorized by the contractors and the Contracting Officer.
Defense Contract Management Command (DCMC)	The purpose of the DCMC is to provide worldwide contract administrative services in support of DOD components and other designated Federal and international organizations. FAR 42.302 further defines the contract administrative functions that may be performed by the cognizant Contract Administration Office (CAO) within the DCMC. The DCMC organization consists of a headquarters and three districts: East and West districts for operations within the United States, and an International district for overseas operations. Some of the more significant functions performed by DCMC components are: Contract Management, Quality Assurance, Engineering, Production and Industrial Resources, Property Management, Financial Services, Industrial Security, Transportation, and Program Support.

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Contract Administration Key Personnel

Key personnel involved in contract administration include:

Role	Responsibilities
Program Integrator (PI)	The PI serves as the Contract Administration Office's focal point for a specific program, leading the program support team (PST). The PST provides functional and technical expertise to support the program. The PI provides reports to the program management office (PMO) and the DCMC chain of command.
Administrative Contracting Officer (ACO)	The ACO performs contract administrative functions as assigned by the Procuring Contracting Officer (PCO). FAR 42.302 (a) lists 69 functions normally performed by the ACO. The PCO may retain responsibility for some of these functions, but may also assign additional functions to the ACO in accordance with the FAR.
Termination Contracting Officer (TCO)	After the Contracting Officer (the PCO or ACO, depending on which has the authority) issues a notice of termination, the TCO is responsible for negotiating any settlement with the contractor.
Contracting Officer Representative (COR)	Contracting Officers may designate qualified personnel as their authorized representatives to assist in the administration of a contract. This designated individual is referred to as the Contracting Officer Representative. A COR's authority must be specified in writing. It is important to remember that a COR may be personally liable for any unauthorized acts.

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DCMC Involvement

The DCMC does not wait until after contract award to become involved in a program it will administer. The contracting office should invite the DCMC to participate in the solicitation, evaluation, and award phase as part of the Integrated Product Team (IPT). By getting involved early in the process, some contract administrative problems that a PCO may not be aware of can be avoided.

Procuring Contracting Officer

The PCO handles the procurement from the pre-solicitation phase through contract award, to include signing the contract on behalf of the Government. After contract award, the contract is normally assigned to an ACO for contract administration. However, the PCO still has the overall responsibility for the contract until it is completed and closed out.

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Contract Administration

The post-award phase begins with contract administration. Contract administration can be accomplished by the contracting office at the camp, post, or station, or by a Contract Administration Office. For DOD, most of the CAOs are within the DCMC.

Purposes

The purposes of contract administration are to:

- Protect the Government's interests.
- Avoid or eliminate overlapping and duplication of Government contract administration effort.
- Provide consistent treatment of contractors in the administration of Government contracts.

Role of Contract Administration

The role of contract administration typically includes the following activities:

- Manage Government interest.
- Monitor contractor's processes.
- Ensure contractor is paid.
- Provide program support.

Contract Administration Functions

Contract administration functions are accomplished in or near a contractor's plant for the benefit of the Government. A wide variety of administration functions are performed to ensure performance of a contract or in support of the buying organization.

CAO Functions

The FAR lists 69 functions typically performed by the CAO if they apply, and another 11 functions to be performed if specifically authorized by the buying office.

Examples of CAO functions:

- Administration of normal matters related to such things as certificates, name changes, transportation, packaging, billings, and payments.
- Cost monitoring, including negotiation of forward pricing agreements, negotiation of billing and final indirect cost rates, and determination of allowable cost.
- Ensuring contractor compliance with contractual quality assurance requirements, and acceptance of product or service on behalf of the Government.
- Surveillance of progress against production schedules.
- Evaluation and surveillance of contractor engineering efforts and engineering management systems.
- Support to the program, product, and project offices regarding program reviews, program status, program performance, and actual or anticipated program problems.
- Evaluation and surveillance of a number of contractor management systems including Government property administration, compensation, insurance, accounting, quality, purchasing, and purchasing systems.

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Delivery and Contract Closeout

The contract specifies the delivery requirements, including:

- Time and place of delivery;
- Quantity to be delivered;
- Method of delivery; and
- Individual or office with the authority to accept the deliverable.

Deliveries may be made throughout the contract or at the end of the contract. After deliveries are made by the contractor and accepted, the Government must:

- Make payments as prescribed in the contract; and
- Close out the contract.

The CAO and the Contracting Officer have certain responsibilities in closing out the contract.

Privity of Contract

Privity of contract is the legal relationship between parties established by a contract. The Government enters into a contractual relationship with the prime contractor. The prime contractor then enters into a contractual relationship with subcontractors in order to complete the Government contract. No contractual relationship exists between the Government and the subcontractor. The Government can only influence a subcontractor through the prime contractor.

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Contract Modification

A common occurrence in Government contracting is a contract change or modification. The Contracting Officer is the only person authorized to obligate the Government by awarding a contract and making any subsequent contract modifications.

There are two types of modifications that a Contracting Officer may execute:

- Bilateral Modifications – Signed by the contractor and the Contracting Officer.
- Unilateral Modifications – Signed by the Contracting Officer.

Type of Contract Modification	Description
Bilateral Modification	A bilateral modification, also called a supplemental agreement, is used to: • Make an adjustment to the contract price as a result of the issuance of a change order; • Definitize letter contracts; and • Incorporate any other agreements of the contracting parties.
Unilateral Modification	A unilateral modifications is used to: • Make an administrative change (written change to the contract that does not affect the substantive rights of the contracting parties); • Issue a change order (see below); • Make a change authorized by contract clauses (e.g., Options clause); or • Issue a termination notice.

Change Order

A change order, signed by the Contracting Officer, directing the contractor to make a change prior to agreement on terms and conditions, as authorized by the contract's Changes clause (FAR 43.101).

The Changes clause allows the Contracting Officer to make changes within the scope of the contract in: (a) drawings, designs, or specifications when the supplies to be furnished are to be specially manufactured for the Government, (b) method of shipment or packing, or (c) place of delivery.

Constructive Change

The execution of bilateral or unilateral modifications by the Contracting Officer is the authorized

means of making changes to a contract.

Some action or a failure to act on the part of the Government may result in a constructive change. The individual that effects the constructive change may be held personally liable for the additional cost.

A constructive change is an unauthorized change that requires the contractor to perform beyond requirements of the contract. Usually, it occurs when a Government official, other than the Contracting Officer, interacts with the contractor. However, a Contracting Officer acting outside his/her authority can effect a constructive change.

As a result of constructive changes, the contractor may be entitled to additional compensation for the cost associated with work performed outside of the contract.

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Contract Closeout

Contract closeout occurs after the contract is physically completed. A contract is physically completed when:

- The contractor completes all deliveries and the Government has inspected and accepted the goods; or
- The contractor has performed all services and the services have been accepted by the Government.

The procedures for the closeout of contract files are found in FAR 4.804. The CAO normally initiates the closeout procedures, but the PCO has the ultimate responsibility for closing out the contract.

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Lesson 15: Earned Value Management

The Challenge of Earned Value

The most difficult part of program management is knowing:

- If the program is on schedule,
- If the program is costing more than planned, and
- What can be done if the program deviates from the plan.

Earned Value Management provides the processes and information necessary to manage the program effectively. Without Earned Value Management, there is little more than guesswork. The following is an example of what could happen if you don't use Earned Value principles to manage the cost, schedule, and performance of your program:

The contractor on a recent program had planned to spend $10 million during the first 6 months of the contract.

- The contractor met that target, and legitimately billed the Government for $10 million.
- Unknowledgeable observers were pleased to see that the contractor was on track.
- However, the Earned Value analysis showed that the contractor had spent that amount on half the work that had been planned.
- Instead of being on track, the work was significantly behind.

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Earned Value: An Analogy

The following familiar example of taking a cross-country trip is used to help illustrate the problem. Managing a program is similar in many ways to taking a trip across the country.

In Managing a Trip...

- There is a fixed destination.
- Resources (time and money) are finite.
- Driving speed and daily mileage can be monitored and corrected.

In Managing a Project...

- There is a project to complete.
- Resources (time and money) are finite.
- The work pace and daily progress can be monitored and controlled.

The Task or Work

Imagine that you must drive across the country. You:

- Must travel from San Diego, CA to New York, NY - about 3,000 miles.
- Plan to take 10 days to complete the trip.

- Budget about $2,000 to pay for gas, food, and lodging.

The Apparent Status

For a 3,000-mile trip costing $2,000, over 10 days:

- You need to drive about 300 miles per day.
- You plan on spending about $200 per day.

This isn't a frantic pace. The trip seems reasonable, and could even be fun. In fact, after traveling for 3 days, you have traveled 1,000 miles and spent $500.

- You are ahead of your 900-mile goal.
- You spent less than your planned $600.
- You expect good roads and weather ahead.

This trip seems to be going well. **Or is it?**

The Real Status

Looking at the trip a little closer, you have traveled 1,000 miles and spent $500, but:

- You spent $150 and a full day to replace the fan belt in Needles, CA.
- You backtracked to pick up the forgotten family dog, which caused you to start the trip all over.
- Your "spontaneous" detour to the Grand Canyon caused a "minor" delay, adding more miles and dollars.

Three days and $500 into the trip and the destination is not much nearer than when you began. The problem with the initial observation is that the miles traveled and dollars spent had little relation to the actual progress toward your destination.

There has to be a better way.

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Creating a Realistic Measure of Progress

Progress on the trip must be tied to achieving objective milestones.

- In planning the trip, specific cities are identified as daily milestones.
- The budget is distributed across the trip, assigning a specific amount to each city.
- The "value" of reaching each city is defined as the amount budgeted to get there.

Goal	Time	Miles	Budget
Phoenix	Day 1	300	$200
Grand Canyon	Day 2	600	$400
Albuquerque	Day 3	900	$600
Amarillo	Day 4	1,200	$800
And so on, until...			
New York City	Day 10	3,000	$2,000

Creating an Objective Measure of Progress

Objective measures for assessing progress toward a goal are based on the project plan that integrates the work scope, schedule, and budget:

Elements	Examples
Work Scope	Reach Amarillo
Schedule	Day 4
Budget	$800

Objective measures of performance provide information useful to the management decision process.

Decisions Based on Objective Measures

Knowing the true status can help make decisions that will achieve the objective. At the end of day 3, you only made it to Phoenix. Compared to the plan:

- The trip is 2 days behind schedule and $300 over budget so far.
- Maintaining this pace, the trip could take up to 30 days and $5,000 to complete!
- Even if you resumed the originally planned pace and budget from this point on, you will arrive in New York 2 days late and $300 over budget.
- To arrive on time you must average 386 miles each day.

With this information, you can manage the cost and schedule impacts to the trip.

	Plan			Actual		
Goal	**Time**	**Miles**	**Budget**	**Time**	**Miles**	**Cost**
Phoenix	Day 1	300	$200	Day 3	500	$500
Grand Canyon	Day 2	600	$400			
Albuquerque	Day 3	900	$600			
Amarillo	Day 4	1,200	$800			

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What Is Earned Value Management?

Earned Value Management is a management tool that:

- Relates the scope of the work to its associated budgets and schedule.
- Measures the work progress in objective terms.
- States the value of the work completed in dollars, or other measurable units.

When the plan integrates work scope, schedule, and budget, and project status is determined using objective measures, then the true status of the effort is known.

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Earned Value Management Overview

An Earned Value Management System is a series of processes that relate scope of the work with schedules and budgets. An Earned Value Management System will:

- Establish a comprehensive work plan known as the Performance Measurement Baseline.
- Measure performance against this baseline using objective measures.

Scope, Schedule, and Budget

An effective Earned Value Management System must develop a plan that integrates the work scope with the schedule and budget. The system must use objective measures to determine the value of the work completed compared to the plan.

<table>
<tr><th></th><th>Scope</th><th>Schedule</th><th>Budget</th></tr>
<tr><td>Work Planned</td><td>What work is scheduled?</td><td>When is it scheduled?</td><td>How much is budgeted?</td></tr>
<tr><td rowspan="2">Work Completed</td><td>What work was done?</td><td>When was it done?</td><td>How much was budgeted for it?</td></tr>
<tr><td colspan="3">How much was actually spent?</td></tr>
</table>

Linking **scope, schedule, and budget** is critical to the success of any Earned Value Management System.

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Data Elements

A management system consistent with Earned Value Management principles provides three data elements useful in assessing the status of a project:

- The budgeted value of the work planned.
- The budgeted value of the work completed, or Earned Value.
- The Actual Costs incurred.

The Plan is the cumulative amount budgeted for the work by a given date.

Earned Value is the sum of the amount budgeted for the tasks completed so far.

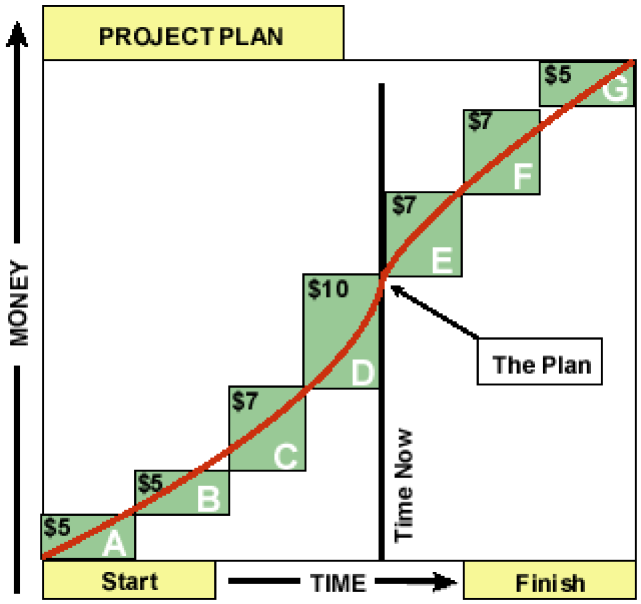
Actual Costs are the costs experienced in accomplishing the tasks completed so far.

The Plan

The Plan is known as the Performance Measurement Baseline (PMB) Shown below are seven tasks of a sample plan (labeled A, B, C, etc.). Each task has resources and schedule allocated to it. The solid line shows the PMB.

The PMB:

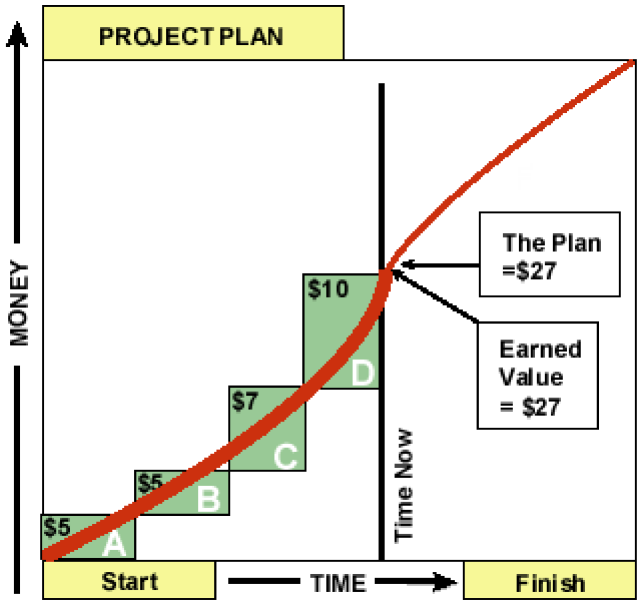
- Represents the budget and schedule associated with each task.
- Depicts:
  - The work to be done,
  - When the work is expected to be accomplished, and
  - The "budgeted value" of that work.



Earned Value - Case 1

The value of the work performed is stated in terms of its budget. This is known as the project's Earned Value.

- If the work is going according to plan, tasks A, B, C, and D are complete.
- The project's Earned Value is the sum of the budgets of completed tasks—$27 in the example shown below.

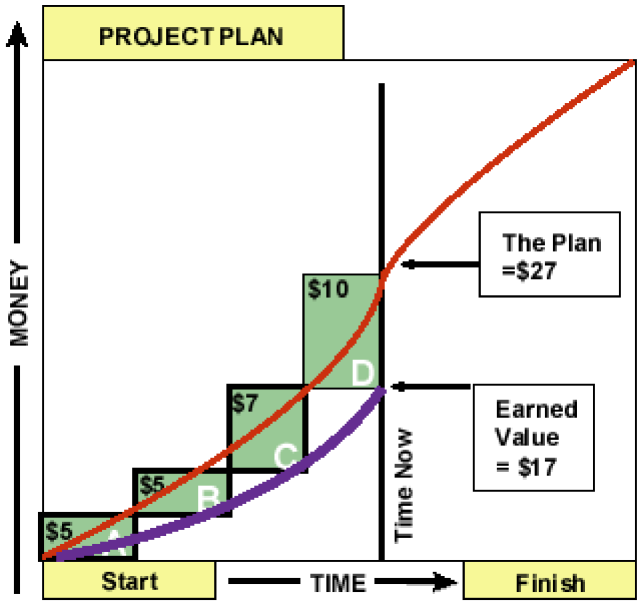


Earned Value - Case 2

However, if only tasks A, B, and C are complete:

- The work is behind schedule, because task D was also supposed to be done.

- The project's Earned Value is the sum of the budgets of completed tasks A, B, and C, or $17.

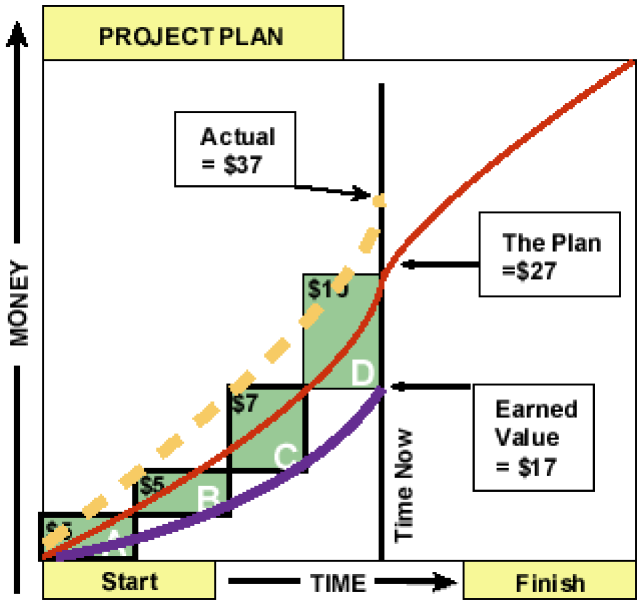


Actual Costs

As work is accomplished, and costs are accumulated, those costs can be tracked and compared to the value of work.

Depending on the efficiency and pace of the work, actual costs may turn out to be:

- The same as the Earned Value,
- Or lower,
- Or higher.



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Comparing Data Elements

By comparing these three data elements—: the Plan, the Earned Value, and Actual Costs—the cost and schedule status of the program can be determined.

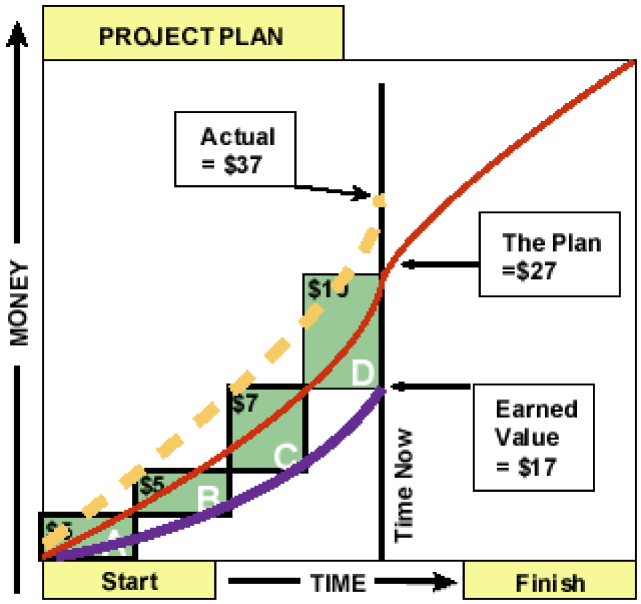
Earned Value Output: Schedule Status

To determine the **schedule status**, compare the **Earned Value,** or value of the work performed, to the **planned value**, to derive the schedule status in dollar terms.

Example:
Earned Value = $17
The Plan = $27

The project was planned to complete $27 worth of work, when in fact, only $17 worth of work was completed.

The project is $10 **Behind Schedule**.



Earned Value Output: Cost Status

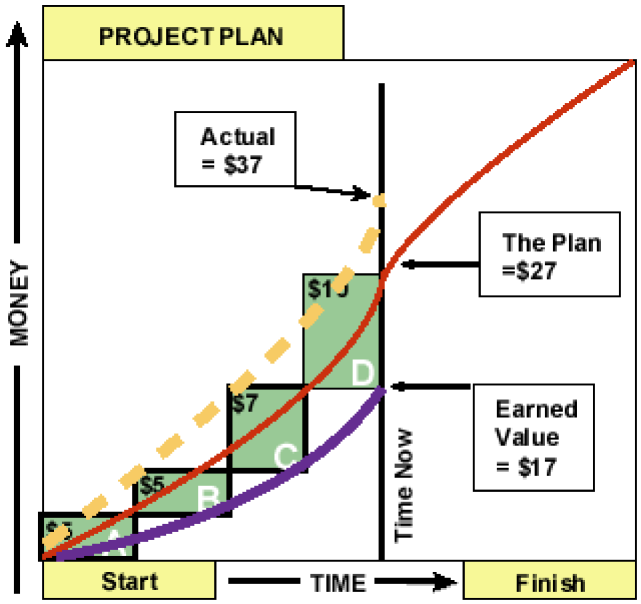
To determine **cost status**, compare the **Earned Value,** or value of the work performed, to the **actual cost** incurred to find the project's cost status.

Example:

Earned Value = $17
Actual Cost = $37

The project has incurred a cost of $37 to achieve only $17 worth of work.

The project is $20 **Over Budget**.



Cost and Schedule Status Examples

The table below shows several examples of different situations where the data elements provided by an Earned Value system can reveal the Schedule and Cost Status of a program.

Plan	Earned Value (EV)	Actual Costs	Schedule Status * (Plan vs EV)	Cost Status (Actual vs EV)
$100	$80	$100	Behind Schedule $20	Over Budget $20
$100	$100	$100	On Schedule	On Budget
$80	$100	$80	Ahead of Schedule $20	Under Budget $20
$100	$120	$140	Ahead of Schedule $20	Over Budget $20
$100	$80	$60	Behind Schedule $20	Under Budget $20

* Note that the Schedule status is measured using dollars, not time.

This indicates that the program is ahead (or behind) by an amount of work whose budgeted value is as shown.

Integration Is the Key

Earned Value Management Systems must have the ability to integrate the work with the associated budgets and schedule. When an integrated plan is developed, program managers are able to:

- Compare the value of the work performed to the actual costs incurred and to the value of the work planned.
- Use this information to identify and take appropriate actions in a timely manner to mitigate

costs and schedule impacts.

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Earned Value Management Systems

Earned Value Management Systems use the information derived from the three data elements to manage the day-to-day program operation. An Earned Value Management System must be able to perform several important functions:

- Develop an integrated plan, and
- Measure performance using objective metrics or criteria.

Earned Value Management Systems Criteria

The Earned Value Management Systems Criteria have two primary objectives:

- For contractors to have and use integrated internal management processes of their own choosing.
- For these systems to provide timely and meaningful data for use by both contractor management and Government management.

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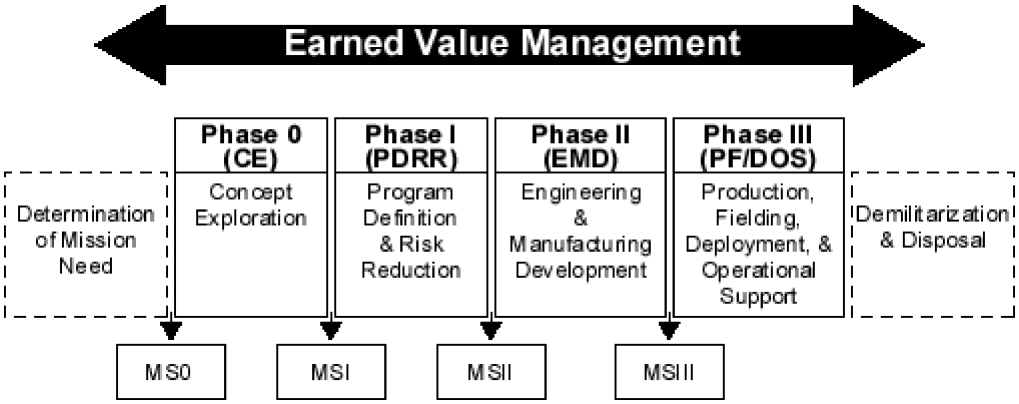
Earned Value Management in Defense Acquisition

Earned Value Management techniques apply throughout the acquisition life cycle when the Government shares the risk with the contractor. The visibility and management control required by Earned Value Management principles can help manage project risks.



Higher Risk Programs

The DOD requires contractors to use management systems certified by the Government as consistent with Earned Value Management Systems Criteria (DOD 5000.2-R, Appendix VI).

DOD 5000.2-R mandates the more detailed "Earned Value Management Systems Criteria (EVMSC)" application on higher risk, Non-Firm Fixed Price contracts at the following thresholds:

- $70 million or more RDT&E (in constant FY 96 dollars)
- $300 million or more Production (in constant FY 96 dollars)

These thresholds serve as a "trip-wire" at which the EVMSC are mandatory, and contractor systems will be Government-Certified.

On Non-Firm Fixed Price contracts (Non-FFP) that are less than the dollar threshold values, Program Managers have discretion (as the risk warrants) to require the contractors to apply the full EVMS Criteria. The contractor's system must be Government-certified and use objective performance measures. When the Government requires the contractor's system to meet the full EVMSC, the PM will request the more extensive Cost Performance Report (CPR). The Government will:

- Tailor information requirements to meet management needs, and
- Use contractor formats.

Lower Risk Programs:

The Government requires contractors to apply Earned Value Management Principles to their management processes, yet does not require the system to be certified by the Government.

Program Managers require contractors to use Earned Value Management Principles on all Non-Firm Fixed Price contracts, since the Government shares the risk. When the PM determines risk is not sufficient to warrant the full EVMSC application, the Cost/Schedule Status Report (C/SSR) applies. C/SSR applications are mandatory for contracts:

- Valued at $6 million or more.
- At least 12 months duration.

When the Government requires C/SSR level of earned value, the PM may obtain either the **CPR-No Criteria**, having more data elements, of the less extensive **C/SSR**. For either report selection, the PM will:

- Tailor information requirements to meet management's needs, and
- Use contractor formats.

Cost Performance Report (CPR) – No Criteria

The CPR option gives program managers a selection of up to five formats, each including an array of data elements. The "No-Criteria" refers to the fact that the contractor's management system that produces the reports, is not required to be certified as consistent with the Criteria.

Cost/Schedule Status Report (C/SSR)

The C/SSR option gives program managers a selection of two formats:

- Earned Value information by Work Breakdown Structure (WBS).
- Contractor's explanations and analysis.

Applicability of Earned Value Management

Earned Value Management principles:

- Apply to Government contracts with industry.
- Apply to internal Government projects and activities consistent with the thresholds identified for industry contracts.
- Have been used effectively on commercial business projects, both nationally and

internationally.

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Earned Value Management Systems Criteria Validation

Depending on the risk level, the Government validates or certifies that the contractor's system is consistent with the Earned Value Management System Criteria. The Government does not mandate the use of a specific management system. Contractors will use their own distinct management system. However, the contractor's system must:

- Produce valid, timely, and accurate data.
- Provide the same data to the Government as that used by the contractor.

Earned Value Management Systems Criteria: Details

Earned Value Management System Criteria are used by the Government:

- As guidelines to evaluate the contractor's specific management system.
- To help assess the contractor's system as an integrated whole, not just independent elements.

The Criteria are structured in five areas common to a contractor's management processes:

Organization

Does the contractor's system:

- Define the authorized work?
- Assign responsibilities?
- Define procedures to allocate indirect costs?
- Establish management controls?

Planning, Scheduling, and Budgeting

Does the contractor's system:

- Authorize all the work?
- Schedule all the authorized work?
- Develop key management control points (i.e., the lowest level to be monitored)?

Revisions

Does the contractor's system:

- Maintain baseline integrity?
- Allow no retroactive changes?

Accounting

Does the contractor's system account for:

- Material costs?
- Unit and lot costs?
- Cost summarization?

Analysis

Does the contractor's system provide data that are useful in:

- Depicting contract status?
- Developing estimates?
- Making decisions?

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Earned Value Management Surveillance

Three key players perform joint surveillance:

- The **Contractor** is fully responsible for establishing and maintaining their internal management processes.
- The **Program Management Office** is part of the team that monitors the contractor's ongoing management processes.
- The **Contract Administration Office**, primarily the Defense Contract Management Command (DCMC), performs ongoing surveillance, with an emphasis on insight into the contractor's internal management process and disciplined controls.

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Who Are the Key Players?

As previously stated, there are three primary players related to Earned Value Management:

The Program Management Office (PMO)

The role of the PMO is to:

- Send a clear message to the contractor that Earned Value Management principles are important to a well-managed program.
- Ensure that PMO staff members are properly trained to perform their Earned Value Management roles.
- Lead the technical staff or Integrated Product Team (IPT) to review the contractor's work plans within 6 months after award.

Defense Contract Management Command (DCMC)

DCMC has the primary role of surveillance. However, joint surveillance is conducted by a team consisting of DCMC, Program Office, and contractor personnel.

- Surveillance is the basis for having confidence in the contractor's discipline, and adherence to their own internal procedures.
- Surveillance allows the Government to monitor contractor system operation.
- Surveillance ensures the contractor's system continues to meet contract EVM requirements and provides valid, accurate, and timely management information.

Contractor Management

The contractor role as a key player is obvious in that they perform the work required by the contract. The contractor will identify key management control points, called Control Accounts, appropriate to

their organization and type of work. The managers of these key accounts are called Control Account Managers (CAMs).

CAMs are senior technical personnel who have several important functions:

- Develop near-term work packages and far-term plans.
- Assign and schedule the work.
- Maintain the project status by tracking work planned, work performed, and actual costs.
- Analyze status and revise plans as necessary.
- Develop estimates of the cost at completion.

The CAM functions are the core of a contractor's Earned Value Management System.

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Integrated Baseline Review (IBR)

DOD 5000.2-R requires program managers and their technical staffs or IPTs to review contractor-planning baselines within 6 months after contract award. The program manager's review of a contractor's performance measurement baseline (PMB) is known as an Integrated Baseline Review (IBR).

The IBR's goals are to:

- Ensure reliable PMBs are established that integrate technical work, schedules, and resources.
- Improve the use of contractor performance data by managers.
- Reduce the number of EVMS Criteria management system reviews

An IBR may produce disagreements, but the contractor cannot fail an IBR. When system concerns surface, the PM will refer them to the cognizant surveillance organization.

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Earned Value Management Implementation

Earned Value Management has proven itself to be a valuable management tool which gives program managers the ability to accurately assess program status.

When successfully implemented, Earned Value Management ensures:

- Disciplined planning processes,
- Baseline work plans that integrate work scope, schedule, and budgets, and
- Objective measures of the work completed.

Earned Value Management Benefits

Earned Value Management principles provide:

- Meaningful control over the work.
- A valid way of relating costs to work accomplished.
- A reliable way of estimating the cost to complete a project.

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Lesson 16: The Systems Engineering Process Environment

Systems Engineering Process (SEP) Disciplines

The various disciplines of Systems Engineering:

- Exist to support the customer.
- Are tied together by the IPPD process.
- Are coordinated and integrated by the IPTs.

Integrated Product and Process Development (IPPD)

IPPD is a management technique that simultaneously integrates all essential acquisition activities through the use of multidisciplinary teams to optimize the design, manufacturing, and supportability processes. IPPD facilitates meeting cost and performance objectives from product concept through production, including field support. One of the key IPPD tenets is multidisciplinary teamwork through Integrated Product Teams (IPTs). (Source: DOD 5000.2-R, Section C, Paragraph 5)

Integrated Product Teams (IPTs)

The Secretary of Defense has directed that the Department perform as many acquisition functions as possible, including oversight and review, using IPTs. These IPTs shall function in a spirit of teamwork with participants empowered and authorized, to the maximum extent possible, to make commitments for the organization of the functional area they represent. IPTs are composed of representatives from all appropriate functional disciplines working together to build successful programs and enabling decision-makers to make the right decisions at the right time. (Source: DOD 5000.2-R, Part 1, Section 1.6)

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Introduction to the SEP Environment

Several disciplines support the overall Systems Engineering Process (SEP):

- Systems Engineering
- Science and Technology
- Test and Evaluation
- Acquisition Logisitics
- Software Engineering
- Production, Quality, and Manufacturing Management

Systems Engineering

Systems Engineering involves design and management of a total system that includes hardware and software, as well as other system life-cycle elements. The Systems Engineering Process is a structured, disciplined, and documented technical effort through which systems products and processes are simultaneously defined and developed.

Systems Engineering is most effectively implemented as part of an overall IPPD effort using multidisciplinary teamwork. (Source: Defense Acquisition Deskbook, 30 Sept 97, Information Structure, Systems Engineering Process 2.6)

Science and Technology

Science and Technology transitions technological developments for use by operational forces. Science and Technology programs:

- Demonstrate new and emerging technologies that have a direct application to military systems.
- Are intended to be implemented into future military systems to support military needs, solve military problems, and provide a sound basis for acquisition decisions.

(Source: Defense Acquisition Deskbook, 30 Sept 97, Information Structure, Science and Technology Topic 2.2)

Test and Evaluation

Test and Evaluation is a process that compares a system or components against requirements and specifications through testing. The results are evaluated to assess progress of design, performance, supportability, etc.

Developmental Test and Evaluation is an engineering tool used to reduce risk throughout the defense acquisition cycle. Operational Test and Evaluation involves the actual or simulated employment, by typical users, of a system under realistic operational conditions.

(Source: Defense Acquisition Deskbook, 30 Sept 97, Information Structure, Test and Evaluation Topic 2.8)

Acquisition Logistics

Acquisition Logistics is a multifunctional, technical management discipline associated with the entire life cycle of a system. The principle objectives of Acquisition Logistics are to ensure that:

- Support considerations are an integral part of the system's design requirements so that the system can be cost-effectively supported throughout its life cycle.
- The infrastructure elements necessary for the initial fielding and operational support of the system are identified and developed and acquired.

The majority of a system's life-cycle costs can be attributed directly to operations and support costs after the system is fielded. Because these costs are largely determined early in the system development period, it is vitally important that system developers evaluate the potential operational and support costs of alternative designs and factor these into early design decisions. (Source: Defense Acquisition Deskbook, 30 Sept 97, Information Structure, Acquisition Logistics 2.6.J)

Software Engineering

Software Engineering is the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of systems engineering to software.

In general, software engineering comprises all the activities performed to support the translation of a user need into a product. That product includes hardware and software.

DOD Software Acquisition Management requires an understanding and application of best

management practices and regulatory requirements that apply to the software planning, acquisition, qualification, and system integration of DOD Automated Information Systems (AIS), Command, Control, Communications, Computers and Intelligence (C4I) Systems, and Weapon Systems.

Production, Quality, and Manufacturing Management
(Called Manufacturing and Production in Deskbook)

The goal of the Production, Quality, and Manufacturing Management discipline is to ensure the producibility of the system design. Producibility is the relative ease of manufacturing an item or system. Designing in producibility reduces both schedule and cost risks.

Manufacturing and Production activities are those activities in weapon system acquisitions associated with the concurrent development and maturation of the product design for producibility and the related new or modified manufacturing processes, and the establishment of the needed production capability. Effective design for producibility can accelerate product introduction, increase quality, and reduce overall cost. Designing in producibility reduces the risk in both schedule and cost for design changes later, when costs to change are much higher. Producibility and manufacturing process efforts should start not later than Milestone I, Approval to Begin a new Acquisition Program, and continue through production. (Source: Defense Acquisition Deskbook, 30 Sept 97, Information Structure, Manufacturing and Production. 2.6.D)

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Roles and Responsibilities

Technical Management Partnership

The Government and Contractor work together as part of the IPT process to transform broad operational requirements into a fielded system.

The Government is concerned primarily with:

- Managing the total program.
- Meeting the user's requirements.

The contractor is concerned primarily with:

- Designing and developing the system.
- Meeting the Government's contractual requirements.

Comparison of Government and Contractor Activities

The Government and Contractor may perform similar activities. However, each party has a distinct role.

Function	Government Role	Contractor Role
Translate the Need	Translates the operational need into a performance specification.	Translates the system performance specification into technical design specifications.
Define the Design	Establishes system-level performance thresholds and objectives.	Allocates system-level performance thresholds and objectives to subsystems and lower.

Monitor the Design	Monitors program technical progress through IPTs, technical reviews, and periodic program reviews.	Manages and integrates technical design progress using internal management standards.
Assure Design Quality	Verifies contractor performance through review and approval of contractor technical deliverables.	Validates internal and subcontractor technical performance through established quality control standards.
Test the Design	Verifies system performance through conduct of development and/or operational testing.	Validates system performance through internal testing and participation in Government development testing.

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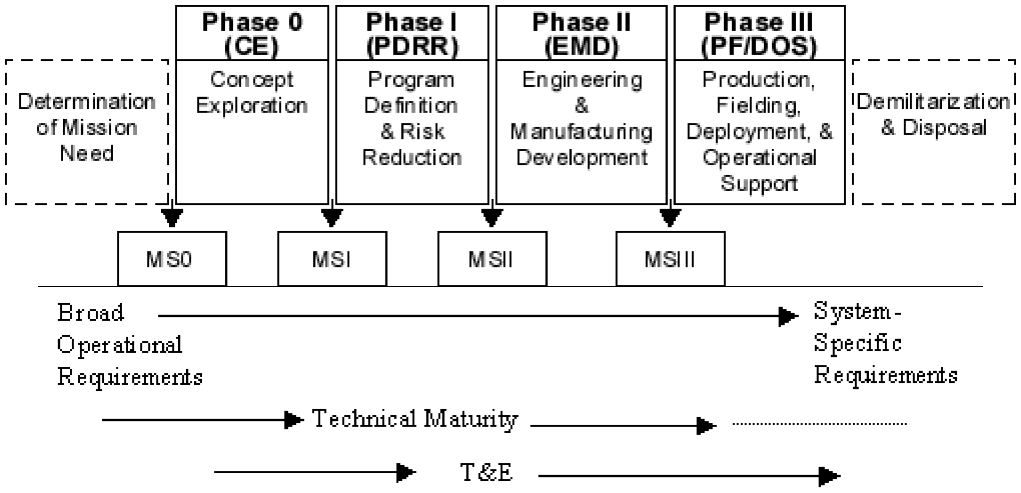
Systems Engineering Process (SEP) Integration

Systems Engineering Disciplines and the Acquisition Life Cycle

The various Systems Engineering activities must be progressively integrated across all phases of the life cycle. These activities must be tailored to fit program needs.



Determination of Mission Need

All acquisition programs are based on identified, documented, and validated mission needs. Mission needs result from ongoing assessments of current and projected capability. Mission needs may seek to establish a new operational capability, to improve an existing capability, or to exploit an opportunity to reduce costs or enhance performance. (If the mission needs cannot be met through the use of non-material solutions (such as change tactics or modify force structure), the need is documented in a Mission Needs Statement (MNS) and validated as discussed in a previous lesson.)

(Source: DOD 5000.2-R, Section 1.4.1)

Concept Exploration

Phase 0 typically consists of competitive, parallel short-term concept studies. The focus of these efforts is to define and evaluate the feasibility of alternative concepts and to provide a basis for

assessing the relative merits (i.e., advantages and disadvantages, degree of risk) of these concepts at the next milestone decision point.

The Analysis of Alternatives is used to facilitate comparisons of alternative concepts. The most promising system concepts are defined in terms of initial, broad objectives for cost, schedule, performance, software requirements, opportunities for tradeoffs, overall acquisition strategy, and test and evaluation strategy.

Following this comparative analysis, the most promising and cost-effective concepts are identified. Based on the preferred concept, the Operational Requirements Document (ORD) is prepared. The preliminary system performance specification is developed to guide conduct of technical management activities in the next phase. (Source: DOD 5000.2-R, Section 1.4.2)

Program Definition and Risk Reduction (PDRR)

During this phase, the program becomes defined as one or more concepts, design approaches, and/or parallel technologies are pursued as warranted. Assessments of the advantages and disadvantages of alternative concepts are refined.

The goal of PDRR is to fully allocate all requirements down to appropriate levels of item performance specifications in order to complete the design. Prototyping, demonstrations, and early operational assessments are included as necessary to reduce risk so that technology, manufacturing, and support risks are well in hand before the next design point.

Based on the selected prototype design, a final system performance specification is prepared to guide the chosen contractor/contractor team in the conduct of detailed design and development during the next phase. Other critical tasks in this phase include: 1) identification of technical design, development, and manufacturing risks, and 2) design of the support system.

Engineering and Manufacturing Development

The primary objectives of this phase are to translate the most promising design approach into a stable, interoperable, producible, supportable, and cost-effective design; validate the manufacturing or production process; and demonstrate system capabilities through testing. Low-Rate Initial Production (LRIP) occurs while the Engineering and Manufacturing Development phase is still continuing, as test results and design fixes or upgrades are incorporated.

Government development and/or operational testing of Engineering Development Models (EDMs) and/or LRIPs will be conducted to ensure that risks have been overcome and that the EDMs and/or LRIP items meet established performance thresholds and objectives. Quantitative and qualitative support system requirements are also identified in this phase. Post-production support planning also begins in this phase. (Source: DOD 5000.2-R, Section 1.4.4)

Low-Rate Initial Production (LRIP) Quantities

The objectives of this activity are to produce the minimum quantity necessary to provide production configured or representative articles for operational test, and thus establish an initial production base for the system; and to permit an orderly increase in the production rate for the system, sufficient to lead to a full-rate production upon successful completion of operational testing. (Source: DOD 5000.2-R, Section 1.4.4.1)

Engineering Development Model (EDM)

A production representative system used during the Engineering and Manufacturing (EMD) phase to resolve design deficiencies, demonstrate maturing performance, and develop proposed production specification and drawings.

Production, Fielding/Deployment, and Operational Support

In this phase, production capability of the chosen contractor is verified, and full-rate production begins. The objectives of this phase are to achieve an operational capability that satisfies mission needs. Deficiencies encountered in Developmental Test and Evaluation (DT&E) and Initial Operational Test and Evaluation (IOT&E) shall be resolved and fixes verified. (The production requirement of this phase does not apply to ACAT IA acquisition programs or software-intensive systems with no developmental hardware components.) (Source: DOD 5000.2-R, Section 1.4.5.1)

Demilitarization and Disposal

At the end of its useful life, a system must be demilitarized and disposed of. During demilitarization and disposal, the PM shall ensure that material determined to require demilitarization is controlled and that disposal is carried out in a way that minimizes DOD's liability due to environmental, safety, security, and health issues. (Source: DOD 5000.2-R, Section 1.4.6)

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Lesson 17: The Systems Engineering Process

IPPD: Satisfying User Requirements

The Integrated Product and Process Development (IPPD) approach includes business, managerial, and technical components. These components work in an integrated manner to ensure that an optimally balanced system is evolved that meets the user's operational requirements.

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Systems Engineering Overview

As the technical component of IPPD, Systems Engineering:

- Transforms operational needs and requirements into an integrated system design solution through concurrent consideration of all life-cycle needs (i.e., development, manufacturing, test and evaluation, verification, deployment, operations, support, training, and disposal).
- Ensures the compatibility, interoperability, and integration of all functional and physical interfaces, and ensures that the system definition and design reflect the requirements for all system elements: hardware, software, facilities, people, and data.
- Characterizes and manages technical risks.

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Systems Engineering: Maintaining a Balance

Systems Engineering manages risk by establishing and maintaining a proper balance between the system solution and factors that directly impact that solution. These factors include:

- Performance
- Cost
- Schedule

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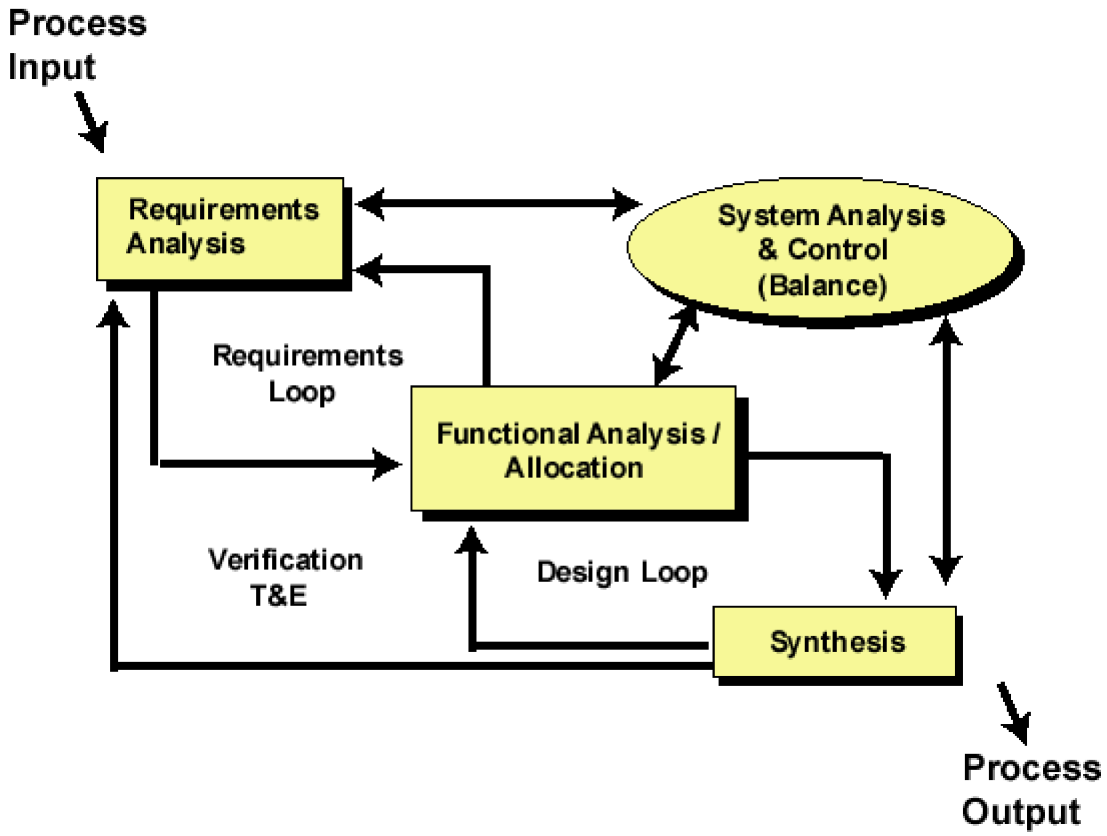
The Systems Engineering Process (SEP)

The Systems Engineering Process (SEP):

- Is a problem-solving process.
- Is iterative in nature (repeats steps).
- Translates the user's need into design criteria, and eventually into designs for new or improved systems.
- Ensures an integrated approach by orchestrating the activities of various technical disciplines.

The Systems Engineering Process Mandated by DOD 5000.2-R



Process Input

Inputs can be user requirements, new technology, results from a previous program phase, environmental constraints, and/or anything else that defines constraints or requirements of the program.

Requirements Analysis

Requirements Analysis is the process of establishing and refining system performance thresholds and objectives (e.g., what must be done, by whom, and how well), as well as any system performance constraints (e.g., environmental, size, weight).

A good Requirements Analysis will:

- Define the system mission.
- Define customer/user needs.
- Define operations & support concepts.
- Define how requirements are to be verified.

Throughout the acquisition process, the program office shall work with the user to establish and refine operational and design requirements that result in the proper balance between performance and cost within affordability constraints.

Requirements analysis shall be conducted interactively with functional analysis/allocation to develop and refine system-level functional and performance requirements and external interfaces, and provide traceability among user requirements and design requirements. (Source: DOD 5000.2-R (Para 4.3))

Functional Analysis/Allocation

The Functional Analysis/Allocation step determines and documents all functions the system must perform (e.g., fly, land, carry, detect). These functions are decomposed to the lowest levels necessary to define the subsystems needed to form the complete system.

Functional Analysis/Allocation shall be performed interactively to define successfully lower level functional performance requirements, including functional interfaces and architecture.

Functional and performance requirements shall be traceable to higher level requirements. System requirements shall be allocated and defined in sufficient detail to provide design and verification criteria to support the integrated system design. (Source: DOD 5000.2-R (Para 4.3))

Synthesis

The Synthesis step (referred to as Design Synthesis and Verification) defines the physical architecture, and designs the system to achieve the functions and subfunctions identified in the Functional Analysis/Allocation step.

Synthesis is part of the following loops:

- Design Loop: Using the design loop, the evolving design is compared iteratively to the system functions to ensure that each can be performed and supported.
- Verification Loop: Using the verification loop, testing and other methods are implemented to ensure that the design meets user operational needs originally identified in Requirements Analysis.

Design Synthesis and Verification

Design Synthesis and Verification activities shall translate functional and performance requirements into design solutions to include:

- Alternative people, product, and process concepts and solutions.
- Internal and external interfaces. These design solutions shall be in sufficient detail to verify requirements have been met.

The verification of the design shall include a cost-effective combination of design analysis, design modeling and simulation, and demonstration and testing. The verification process shall address the design tools, products, and processes. (Source: DOD 5000.2-R (Para 4.3))

System Analysis and Control

System Analysis and Control provides the tools within the Systems Engineering Process to manage risk and to control and gain insight into the design, development, testing, support, quality assurance, and manufacturing processes.

Process Output

The output of SEP is not the system itself; it is, rather, the integrated solution to the user requirements. The actual outputs will be (depending on phase):

- System and item specifications.
- Drawings.
- A technical database that contains the data used to develop the design (e.g., trade studies, risk plans, technical performance measures, test plans and reports).

This information provides a basis that can be used to further develop the design or as a basis for further decisions.

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Government and Contractor Roles

The Government and Contractor roles in the SEP are summarized below.

Government	• Ensures that the contractor has responsible design, testing, and manufacturing proceses. • Identifies and manage technical risks. • Verifies that technical solutions satisfy customer requirements.
Contractor	• Uses SEP in planning, designing, and internally testing the system and its required support components.

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SEP Outputs

Specifications Functions

Specifications ensure that the fielded system meets the user requirements and conforms with other process inputs. Specifications perform two broad functions in the Systems Engineering Process:

1. Specifications act as program constraints (inputs).
   Examples:

   - Detail specifications (Industry and Military).
   - Performance specifications (Industry and Military).
   - Interface specifications.

2. Specifications describe product configuration baselines.
   Example:

   - Program-unique specifications.

Performance-Based Specifications and Standards

Programs should document the system design by:

- Using performance-based specifications as preferred standards.
- Choosing specifications and standards adopted by industry.
- Requiring control of interfaces between the elements of the system.
- Encouraging alternative solutions by contractors.

Detailed specifications and standards are no longer routinely imposed on the contractor by the

Government.

Program-Unique Specifications

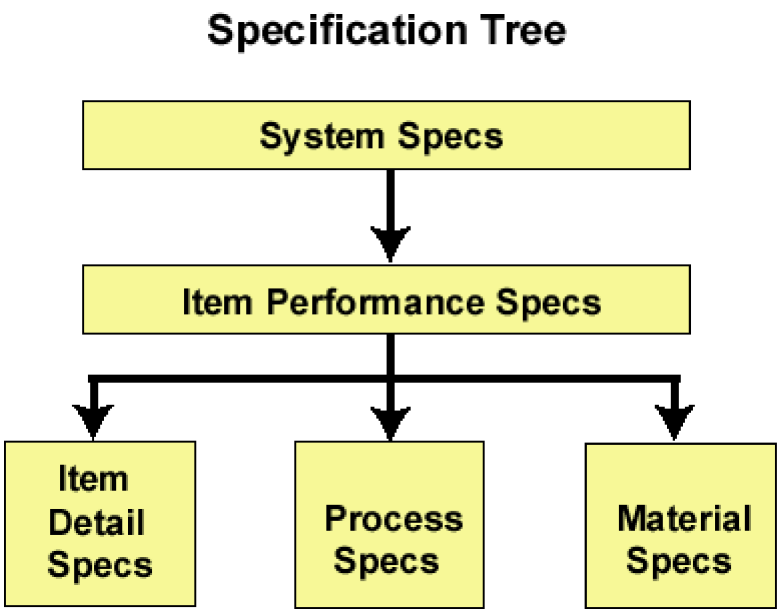
In general, a program-unique specification describes a product or a system. There are several types of program-unique specifications encountered in DOD programs:

- System Specifications.
- Item Performance Specifications.
- Item Detail Specifications.
- Process Specifications.
- Material Specifications.

These specifications are derived from all the previous steps and become the SEP outputs.

Specification Development

Specification development is a top-down process that occurs throughout the entire acquisition process. This process begins by identifying the System Specifications, followed by the Item Performance Specifications. Next, the Item Detail, Process, and Material Specifications are defined.



System Specifications

The system specifications describe what the entire system must do.

System Specifications:

- Can be thought of as the translation of the Operational Requirements Document (ORD) into technical requirements.
- Contain requirements the system must meet and describe how they will be verified or tested.

Item Specifications

There are two types of Items Specifications:

- Item Performance: Item Performance Specifications describe the performance required of the

major subsystems below the system level (e.g., "design to" requirements).
- Item Detail: Item detail specifications include specific design parameters (e.g., "build to" requirements).

Process and Material Specifications

Process Specifications define processes to be performed during fabrication, such as:

- Welding
- Soldering
- Bonding

Material Specifications define raw materials or semi-fabricated material used in fabrication, such as:

- Copper pipes
- Aluminum wire

Specification Flowdown

Program-unique specifications are developed with increasing levels of detail as the design matures. Details developed at each level "flow down" to lower levels forming the design requirements at that level.

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SEP System Analysis and Control

The System Analysis and Control element involves both Government and contractors equally in:

- Evaluating system effectiveness.
- Balancing cost, schedule, and risk parameters for development.
- Controlling the system configuration as it progresses from a concept to a completed product.

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System Analysis and Control Tools

There are many tools available to manage risk and to control and gain insight into a design:

- Work Breakdown Structure (WBS)
- Trade-Off Studies
- Technical Risk Management
- Technical Performance Measures
- Configuration Management
- Integrated Data Management
- Interface Controls
- Technical Reviews

Work Breakdown Structure (WBS)

The Work Breakdown Structure (WBS) is the basis for communication throughout the acquisition process. A WBS defines a defense system in product terms–hardware, software, services, data, and facilities–and relates them in a family tree that displays the relationships of the product(s) to each other and to the end product.

This product orientation provides a reasonable, consistent framework for defining defense acquisition programs. The WBS captures years of experience in weapon and automated information systems acquisitions, yet allows flexibility to accommodate any new program's needs. (Source: Defense Acquisition Deskbook, 30 Sept 97, Information Structure, WBS, 2.6.2)

Trade-Off Studies

Trade-Off Studies examine alternatives among requirements and designs at the appropriate level of detail to support decision making and lead to a proper balance between performance and cost.

Technical Risk Management

Technical Risk Management identifies and evaluates potential sources of technical risks based on the design and its associated technology conducted throughout the design process. Technology transition planning and criteria are part of the overall risk management effort. (Source: DOD 5000.2-R, Part 4, Section 4.3)

Technical Performance Measures

Technical Performance Measures determine how well the technical development and design are evolving relative to what was planned and relative to meeting system requirements in terms of performance, risk mitigation, producibility, cost, and schedule. Performance measures must be traceable to performance parameters identified by the operational user (i.e., one of the key performance parameters is on track or in trouble).

Configuration Management

Configuration Management ensures the functional and physical characteristics of an item and its documentation are properly developed according to the Systems Engineering Process. There are four basic functions of Configuration Management:

- Identification
- Control
- Audit
- Status Accounting

Each must work together to effectively control the design.

Configuration Identification

Configuration Identification involves:

- Selection of the items to be managed–the Configuration Items.
- Development of documentation (specifications and drawings) and issuance of identifiers, such as:
    - Nomenclature
    - Part number
    - Serial or lot number
    - Specification and drawing number

Configuration Control

Configuration Control of a Configuration Item (CI) involves a systematic change process that begins with the Configuration Baseline. For each required change, the following processes are implemented:

- Creation of a proposal to change the baseline.
- Justification of the need for the change.
- Evaluation of the impact of the change.
- Coordination among the IPT members.
- Approval (or disapproval) by the PM.
- Implementation by the IPT and/or contractor.

Configuration Audit

Configuration audits are conducted to verify that a completed Configuration Item or system and its documentation:

- Agree with each other.
- Are complete and accurate.
- Satisfy program requirements (meet specifications).

There are two recommended types of configuration audits:

- Functional Configuration Audit (FCA):

  The formal examination of functional characteristics that test data for a Configuration Item (CI), prior to acceptance, to verify that the item has achieved the performance specified in its functional or allocated configuration identification.

- Physical Configuration Audit (PCA):

  Physical examination to verify that the configuration item (CI) "as built" conforms to the technical documentation which defines the item. Approval by the Government program office of the CI product specification and satisfactory completion of this audit establishes the product baseline. May be conducted on first full production or first low rate initial production (LRIP) items.

Specific audits will be tailored by each program.

Configuration Status Accounting

Configuration status accounting process is maintained throughout the system life cycle. Status accounting provides current and historical information to:

- Track the configuration of the fielded systems.
- Track proposed and approved changes to the current system configuration.
- Assist in providing the right logistic support for the right configuration.

Integrated Data Management

Integrated Data Management is a system that captures and controls the technical baseline (configuration documentation, technical data, and technical manuals); provides data correlation and traceability among requirements, designs, decisions, rationale, and other related program planning; and establishes a ready reference for the systems engineering effort. (Source: DOD 500.2-R, Part 4, Section 4.3)

Interface Controls

Interface controls ensure that all internal and external interface requirement changes are properly recorded and communicated to all affected configuration items.

Technical Reviews

The Technical Review process demonstrates and confirms completion of required accomplishments and their exit criteria as defined in program planning. Reviews necessary to demonstrate, confirm, and coordinate progress will be incorporated into overall program planning. (Source: DOD 5000.2-R, Part 4, Section 4.3)

Technical reviews are a means of measuring event-based technical progress. Reviews are held at various stages of system design and development to:

- Evaluate progress based on specific, required accomplishments (exit criteria), and
- Determine if the system is maturing sufficiently to warrant proceeding into the next level of development.

Technical reviews are an excellent discretionary means for the program manager to gain insight into the design and development process. These reviews should:

- Be held for a specific purpose and only when the criteria for holding each review has been met.
- Assess SEP outputs to determine design progress and maturity.
- Determine the contractor's readiness to proceed to the next stage.

Government and Contractor Roles

The Government and the contractor have complementary but different responsibilities in the acquisition of defense systems. Therefore, it follows that they each use the System Analysis and Control tools in different ways.

- The Government oversees and gains insight into the SEP through the use of System Analysis and Control tools.
- The contractor uses System Analysis and Control tools to discipline the internal conduct of the SEP, and to facilitate implementation of the SEP by subcontractors.

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SEP and the Life Cycle

SEP Across the Life Cycle

The SEP is a Total System approach to develop a design solution. It is an iterative process that spans all acquisition phases. A concept evolves into a specific system, then necessary subsystems are developed, tested, and integrated into the system. The total system is then tested, manufactured, fielded, supported, and finally disposed of.

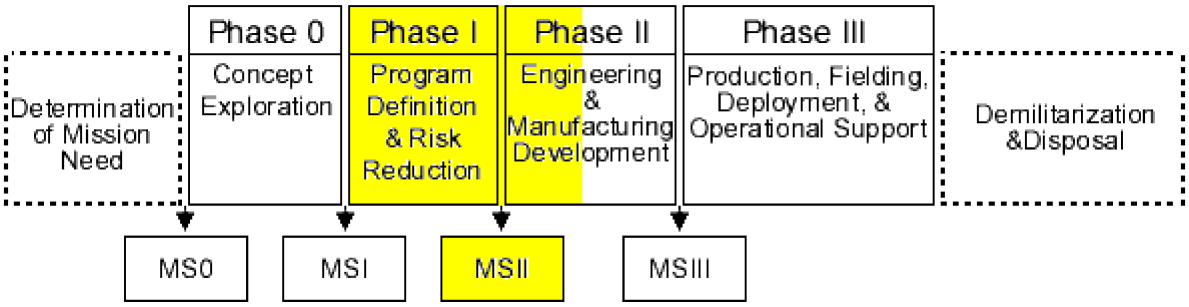
System Concept

During Concept Exploration, user needs are translated into design criteria. This translation is documented using the system performance specifications. The system performance specifications (normally controlled by the Government) translate the Operational Requirements Document (ORD) into technical performance requirements that can be used by the contractor to arrive at a system solution.

Preliminary Design

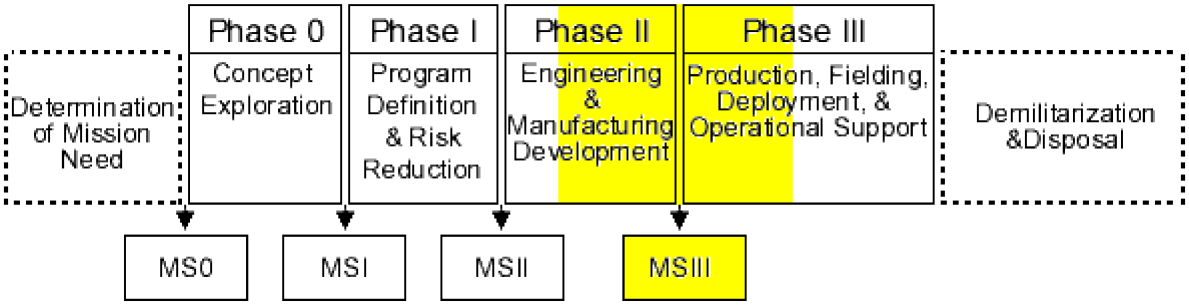
System specifications are completed and item performance specifications begin to be developed in the Program Definition and Risk Reduction Phase. Risks are identified and fully explored. Strategies

are developed and adapted to reduce and manage risks. Early in Engineering and Manufacturing Development, item performance specifications are completed.



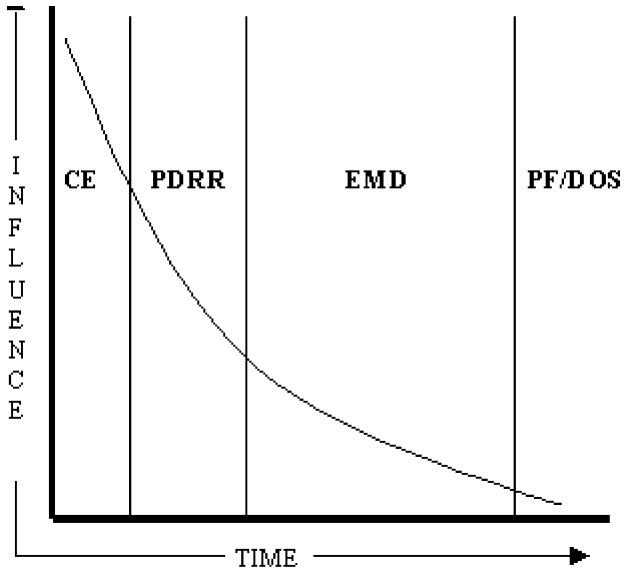
Detailed Design

The detailed design of the system and all of its components, processes, and materials will be completed during the latter part of Engineering and Manufacturing Development or early in Production. Design solutions are documented using item detail, process, and material specifications, associated drawings, and other technical documentation.



Life-Cycle Costs (LCC)

The earlier a decision is made in the life cycle of a system, the more influence it can have on the overall LCC of the system.



Remember, an effective Systems Engineering Process used throughout the development cycle will help meet LCC objectives and enhance cost stability throughout the system's life.

Concept Exploration (CE) and LCC

Choosing a missile versus an aircraft in the Concept Exploration phase can substantially affect the costs throughout the entire life cycle. Once a particular system is selected, a large portion of the total LCC is established.

Program Definition and Risk Reduction (PDRR) and LCC

Key decisions made during this phase cause subsequent decisions to have a decreasing effect on LCC. Some of these include:

- Support concepts.
- Technologies and materials to be used in designing and manufacturing the system.
- Types of training.
- Personnel required to operate and maintain the system.

Engineering and Manufacturing Development (EMD) and LCC

Although often the longest phase in the development cycle, EMD should have only minor influence on the LCC if effective cost/performance tradeoffs were performed in the earlier phases.

Production, Fielding/Deployment and Operational Support (PF/DOS) and LCC

In the final life-cycle phase, there should be little or no impact on the LCC. Ideally, all risk should be known and managed. In practice, system improvements to correct performance or support shortfalls can have an effect on LCC.

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Good Design Characteristics

Characteristics of an Effective Design

It is tempting to define good design only in terms of system performance. While the ability of the system to accomplish its operational mission parameters is an important characteristic, a good design has other equally important attributes.

Effective Design Attributes

In addition to mission performance, an effective system design should exhibit the following attributes:

- The system must be designed to be cost-effectively supportable over its life cycle (e.g., reliable, maintainable).
- The system must be cost-effectively producible. This is an important design aspect as it affects both the materials used and the manufacturing processes.
- The system must be affordable. Cost is a design requirement that weighs equally with performance.
- Finally, a good design must be testable so that the user can verify that it is capable of

accomplishing its assigned mission(s).

Integration of Design Attributes

An integrated effort that uses the IPPD processes and IPTs ensures that:

- All characteristics of a good design are considered in the SEP.
- The major goals of the process are fulfilled to meet user requirement/needs.
- Design issues are addressed early avoiding increases in both acquisition and in the Life-Cycle Cost.
- Risks are identified and managed.

System Design and SEP goals

An effective system design supports the achievement of the following seven SEP Goals:

- **Cost Efficiency**

  The system design should allow the Government to acquire a system that meets performance requirements at a reasonable price. Also, the system design should allow for planned improvements without costing an exorbitant amount.

- **Fully Integrated Software**

  The system design should ensure that software works effectively with the rest of the system and other related systems.

- **Mission Performance**

  The system design should meet all of the user's requirements for accomplishing the operational mission.

- **Producibility**

  The system design should ensure producibility. Producibility is the relative ease of manufacturing an item or system. The characteristics and features of the design can govern whether available manufacturing techniques can be used. Using existing manufacturing techniques enables more economical fabrication, assembly, inspection, and testing.

- **Technology Transition**

  The system design should take full advantage of new technology developed by laboratories for other systems. Technology transition can reduce the cost of new technology development.

- **Supportability**

  The system design should ensure supportability. Supportability requires that the system design and planned logistics resources (including the logistic support elements) meet system availability and wartime utilization requirements.

- **Testability**

  The system design should ensure testability. Testability is the ability of the user to verify that the system is capable of accomplishing its assigned mission under realistic operational conditions.

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Lesson 18: Science and Technology in the Acquisition Process

U.S. Technology Posture

Defining Science and Technology

Science is the broad body of knowledge derived from observation, study, and experimentation. It includes:

- Physics
- Biology
- Material sciences
- Chemistry
- Geophysics
- Mathematics

Technology is the practical application of scientific knowledge.

Science and Technology Base

Many past technological advances were linked to defense development. Several "firsts" were developed to ensure national security in times of crisis or warfare. Such advances include:

- Telegraph
- Mass-produced jet aircraft
- Stealth technology
- Atomic power
- Laser
- Radar

To ensure dominance in future warfare, the United States is committed to maintaining a solid and strong science and technology program. This technology base is the nation’s premier combat force multiplier.

Technology Transition

Technology transition is a function/goal of the Systems Engineering Process.

- In peacetime, technological superiority is a key element for deterrence of conflict.
- During crisis, technological superiority provides a wide range of options to the Commanders-in-Chief (CINCs), while providing confidence to our allies.
- In war, technological superiority enhances combat effectiveness, reduces casualties, and minimizes equipment loss.

The Military’s Changing Role in Science and Technology

In the mid-1970’s, there was a shift in the origin of new technology breakthroughs. No longer was the

defense establishment the primary source of new technology. Commercial consumer technology began to provide many "firsts." The military emphasis shifted from developing new technologies to leveraging commercially developed applications.

Defense Science and Technology Program Foundations

The Defense Science and Technology program:

- Needs to be grounded in a deep understanding of fundamental science and technology.
- Uses this understanding to create new military capabilities to counter security threats.
- Responds to what the warfighters need.
- Does not duplicate what the commercial marketplace can produce cheaper and faster.

Remember that science and technology play a critical role in peacetime as well as during times of conflict. Our technology base is our foremost force multiplier and an important national economic asset.

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Science and Technology Continuum

Budget Categories

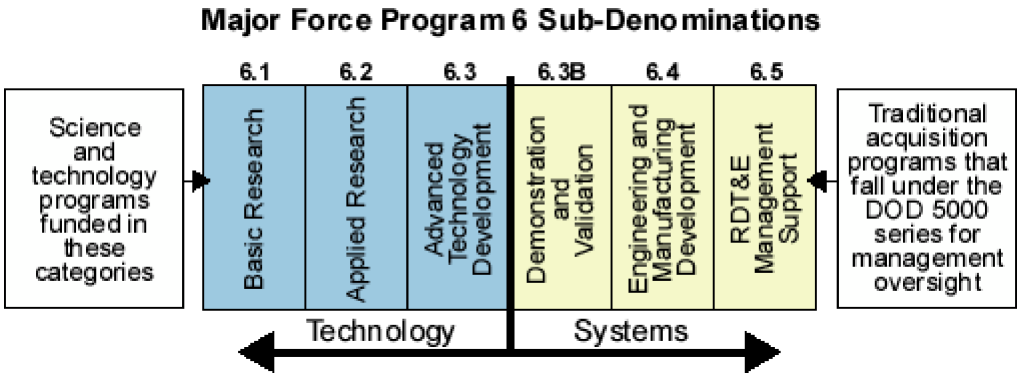
The science and technology program is managed in the following three Research, Development, Test, and Evaluation (RDT&E) budget categories:

- Basic Research (RDT&E Budget Category 6.1)
- Applied Research (RDT&E Budget Category 6.2)
- Advanced Technology Development (RDT&E Budget Category 6.3).

Research, Development, Test, and Evaluation (RDT&E) budget categories are separately funded but related. The difference in funding between acquisition programs and science and technology can be explained by reviewing the RDT&E appropriation.

Research, Development, Test, and Evaluation (RDT&E) Appropriation

The chart below shows the six RDT&E budget categories implemented in the Future Year Defense Plan (FYDP).



Basic Research: Category 6.1

The first applicable RDT&E budget category used to fund basic research is category 6.1. Basic research includes scientific studies that increase fundamental knowledge in fields such as computer

science, chemistry, electronics, and materials. The objective is to create or exploit scientific breakthroughs and guard against technological surprise.

Colleges and universities conduct 60% of DOD's basic research; DOD and Federal Labs conduct 25%; and industry and nonprofit organizations conduct 15%.

Applied Research: Category 6.2

The second applicable RDT&E budget category used to fund applied research is category 6.2. DOD funds applied research through RDT&E budget category 6.2. Applied research:

- Focuses on maturation of technologies before they are considered for transition to advanced development.
- Includes applying basic research to solving specific military problems.

Concepts proving to have merit are formulated into possible technological solutions. These solutions are evaluated based on the feasibility and practicality of their technological application.

Ten Key Areas of Importance to Future Military Needs

Applied research focuses on those technologies in the 10 key areas, as reflected in the Defense Technology Area Plans (DTAPs) that have the highest relative importance to future military needs. The following areas are described in 10 Technology Areas Plans (TAPs):

- Air Platforms
- Biomedical
- Chemical/Biological and Nuclear Defense
- Sensors, Electronics, and Battlespace Environment
- Information Systems and Technology
- Space Platforms
- Ground and Sea Vehicles
- Human Systems
- Materials/Processes
- Weapons

Advanced Technology Development: Category 6.3

The third applicable RDT&E budget category used to fund advanced technology development is category 6.3. This category focuses on the development of components, subsystems, and advanced technology demonstrations with potential application to a variety of similar products rather than application to one specific system.

Technology Progression

The F-117, B-2, and other stealth aircraft provide an excellent example of how technology progresses through basic research (6.1), applied research (6.2), advanced technology development (6.3), and finally into system development.

Basic Research RDT&E Budget Category 6.1

Basic research efforts were conducted in the late 60's and early 70's dealing with mathematical analysis of radar wave reflectivity from various geometric shapes. Other efforts studied the absorption/reflection characteristics of various materials.

Applied Research RDT&E Budget Category 6.2

The basic research efforts led to 6.2-level investigations. The mathematical analysis of geometric shapes evolved into studies of how low-reflectivity shapes could serve as aerodynamic components (air foils, fuselage). Work continued to determine if low absorption materials could serve as structural components of an airframe or be applied to structural components.

Advanced Technology Development RDT&E Budget Category 6.3

Finally, a technology demonstrator was built. Initially, this demonstrator was highly classified. This demonstrator ultimately led to operational aircraft such as the F-117 and B-2.

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Introducing Technology Into Acquisition Phases

Research Application

DOD funds basic research institutes in a dozen Science and Engineering Disciplines, but only a small portion of research findings is incorporated into military or defense systems.

Research is often found to be infeasible for application or not mature enough to be incorporated into the acquisition process. A program manager must decide when it is appropriate to incorporate new technology into an acquisition program.

Twelve Basic Research Science and Engineering Disciplines

The 12 Basic Research Science and Engineering Disciplines funded by the DOD include:

- Physics
- Chemistry
- Mathematics
- Computer Science
- Electronics
- Materials Science
- Mechanics
- Terrestrial Science
- Ocean Sciences
- Atmospheric and Space Science
- Biological Science
- Cognitive and Neural Science

When To Incorporate Technology

The decision to transition new technology into an acquisition program requires:

- An objective assessment of the maturity level of a given technology.
- Cooperation, understanding, and effective communications among the users, acquirers, and Science and Technology managers.

Determination of Mission Needs

Science and Technology managers and users focus on new ideas that could meet the warfighters needs during the Mission Area Analysis. If the analysis shows that a materiel solution is needed, a Mission Need Statement is prepared, and the acquisition process is begun.

Concept Exploration

As concepts are considered, the benefits and risks of the candidate technologies are reviewed to understand the impact of each approach.

- Selecting unproven technology can introduce significant risk.
- Selecting proven technology can pay off in cost, schedule, and performance.

Program Definition and Risk Reduction

As the design matures, introducing new technology can cause significant changes to the system baseline.

- New technology can often be incorporated as a pre-planned product improvement to the original baseline.
- Technologies involving new manufacturing techniques are often incorporated into the design during this phase.

Engineering and Manufacturing Development (EMD)

EMD's goal of maturing and stabilizing the design is often inconsistent with introducing new technology at this point in a program. Insertion of technology into parallel system modifications and Service Life Extension Programs can be planned based on changing user needs, such as:

- Changing threats
- The need for more cost-efficient systems
- New technological opportunities

Production, Fielding/Deployment, and Operational Support (PF/DOS)

During the Production and Fielding/Deployment portions of this phase, new technologies are typically introduced as part of a pre-planned product improvement program.

During the Operational Support portion of this phase, system modifications may be developed that inject new technology into the system throughout its life. These are typically managed as new or distinct programs.

Demilitarization and Disposal

It may be many years between the development of a system and its demilitarization and disposal. New technologies can be used to dispose of these systems properly. Often new technologies are needed to comply with current requirements:

- Legal
- Environmental
- Safety

Principles for Successful Technology Integration

Program managers can reduce the risk associated with integrating technology by adhering to four underlying principles that govern the successful transition of technology into military systems. The

underlying principles for successful technology integration are:

- Ensure technology is focused on critical military needs.
- Establish a technology transition approach to define tasks and resources needed to accomplish the transition.
- Define transition criteria and the implementation method for incorporating technology.
- Conduct periodic reviews in conjunction with laboratories, users, and maintainers.

Criteria for Incorporating Technology

A program office should develop criteria for incorporating advanced technology into an acquisition. The office may consider several criteria, but there are three criteria that have proven to increase success and reduce risk and therefore should be included.

CRITERION	DESCRIPTION
Clear military need	The technology should demonstrate a significant improvement in the defense system.
Fully demonstrated, evaluated, and tested	The more information there is about the proposed technology, the less risk will be involved.
Cost-effective	Anything that drives down the cost of the weapon system has a far greater chance of success.

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Advanced Technology Demonstrations

Advanced Technology Demonstrations (ATDs)

Direct application of efforts in basic and applied research to systems application may be marginal. The technology produced in these two areas is not mature enough to transition directly to systems development. ATDs reduce the risk in transitioning from technology to systems.

Advanced Technology Demonstrations (ATDs) are:

- Projects funded using RDT&E Budget Category 6.3 (Advanced Technology Development).
- Intended to demonstrate technology feasibility and maturity.
- Designed to reduce technical risks and uncertainties at the relatively low cost of informal processes.

Uses of ATDs

ATDs are hardware and software prototypes used for:

- Testing and evaluating non-system-specific solutions to refine basic and applied research.
- Preparing technology for systems development by demonstrating the feasibility and maturity of an approach at a relatively low cost.

Managing and Funding ATDs

Following are important points to remember about ATDs. ATDs:

- Are usually managed by Federal laboratories.
- Demonstrate military utility of a technology before it is transitioned to an engineering community

or program office.
- Are funded by Advanced Technology Development funds (6.3).

Advanced Technology Development Funds (6.3)

This funding category includes all projects that have moved into the development of hardware for demonstration, proof of technology, and/or technological trade-off purposes. Both ATDs and ACTDs are funded with 6.3 funds.

Advanced Concept Technology Demonstrations (ACTDs)

Advanced Concept Technology Demonstrations (ACTDs):

- Are a special case of ATDs, enhanced so that they can be fielded and used by operational forces.
- Were introduced in 1994 to enable rapid, cost-effective introduction of new capabilities.

DOD 5000.2-R recognizes ACTDs as Non-Acquisition programs that provide a means of demonstrating the use of mature technology to address critical military needs.

ACTDs are also:

- A means of demonstrating the use of emerging mature technology to address critical military needs.
- Not acquisition programs, although they are designed to provide a residual, usable capability upon completion.
- Funded to provide adequate support for at least 2 years of field operations.
- Funded with 6.3 (Advanced Technology Development (ATD)) funds.

According to DOD 5000.2-R (Para 2.7):

> "ACTDs are a means of demonstrating the use of emerging or mature technology to address critical military needs. ACTDs themselves are not acquisition programs, although they are designed to provide a residual, usable capability upon completion. If the user determines that additional units can be funded, the additional buys shall constitute an acquisition program with an acquisition category generally commensurate with the dollar value and risk of the additional buy. The nature of the acquisition program depends on what additional development, if any, is needed upon completion of the ACTD. ACTDs shall conduct CAIV-based cost/schedule/performance tradeoffs throughout their planning and execution."

ACTD Characteristics

ACTDs have the following characteristics:

- ACTD candidates are nominated by the services and selected by the Deputy Under Secretary of Defense (Advanced Technology).
- ACTDs focus on the user of the technology rather than the acquisition manager or laboratory.
- ACTDs use parallel demonstrations of technology and doctrine/tactics in an operational environment.

ATD and ACTD Objectives

The objectives of each type of demonstration are shown below:

- ATD Objective: To assess potential military utility.
- ACTD Objective: To decide whether to invest resources based on military utility and requirements.

ACTD Key Points

It is important to remember that ACTDs:

- Are selected at a very high Office of the Secretary of Defense (OSD) level, by the Deputy Under Secretary of Defense (Advanced Technology).
- Have a review panel.
- Emphasize parallel technology development and refinement of operational concepts in the field.
- Do not require all of the documentation that usually applies to acquisition programs.
- Require an informal management plan.

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Lesson 19: Test and Evaluation Overview

Why Test and Evaluate?

Information is critical to managing an acquisition program. This includes information on the capabilities and limitations of the system and risks affecting system cost, development schedule, and performance. The overall goal of T&E is to reduce risk by providing crucial information to decision makers.

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T&E Mandates

DOD Directive 5000.1 provides guidance on how T&E programs shall be structured. Paragraph 1.d.2.e requires that programs be structured to:

- Provide essential information to decision makers;
- Assess attainment of technical performance parameters; and
- Determine whether systems are operationally effective, suitable and survivable.

DOD Regulation 5000.2-R states that test activities shall be part of a strategy to:

- Provide information regarding risk and risk mitigation,
- Provide empirical data to validate models and simulations, and
- Permit an assessment of the attainment of technical performance specifications and system maturity.

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T&E Customers

These Customers:	Use T&E Information to:
Acquisition Managers	• Evaluate the acquisition program for risk management. • Determine if system performance meets thresholds. • Determine if the system has the potential to meet objectives. • Determine the technical changes needed to keep the program on track.
Designers and Engineers	• Evaluate system design and performance. • Identify if design changes are needed. • Provide feedback into Systems Engineering Process. • Update modeling and simulation.
End-users	• Learn how the system performs under operational conditions. • Utilize operational performance characteristics to improve tactics

	• Utilize operational performance characteristics to improve tactics and warfighting capability. • Obtain information to help plan for training and logistics support. • Understand full performance envelope and capabilities.

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Defining Test and Evaluate

TERM	DEFINITION
Test	A program, procedure, or process to obtain, verify, or provide data for determining the degree to which a system (or subsystem) meets, exceeds, or fails to meet its stated requirements. These requirements can be stated in terms of thresholds and objectives. Testing: • Obtains raw data. • Measures specific, individual performance factors (e.g., measuring range). • Is resource intensive.
Evaluate	Reviewing, analyzing, and assessing data obtained from testing to project system performance under operational conditions. Evaluating: • Produces analyzed information from test data, modeling and simulation, or other sources. • Draws conclusions by looking at how the factors interact. • Is intellectually intensive.

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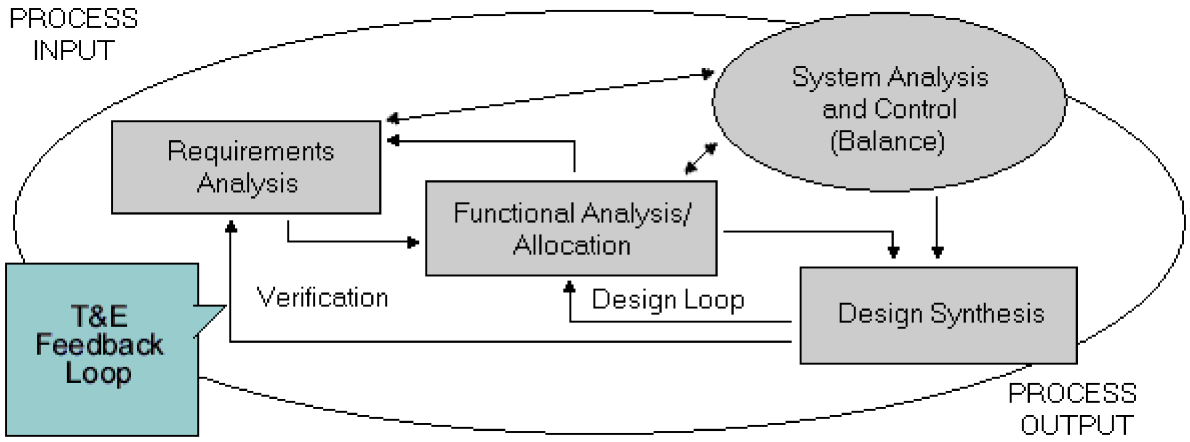
T&E Feedback Loop



T&E is the essential feedback loop contained within the Systems Engineering Process. T&E ensures that the system meets the requirements. The T&E process is repeated as the system evolves from

models to components to production articles and complete systems.

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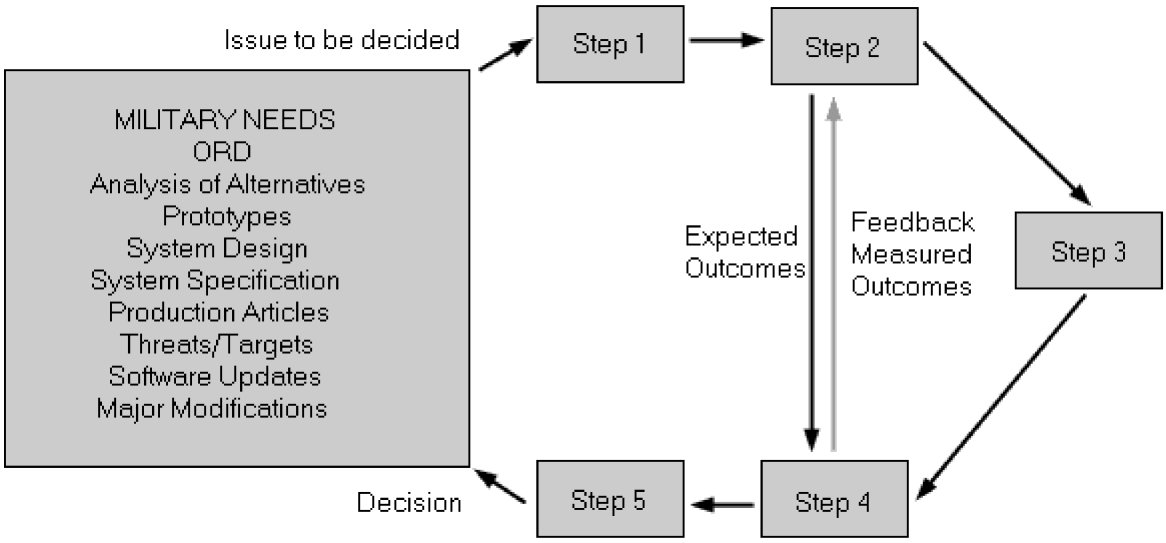
Test and Evaluation Process Overview

The T&E process has five steps that occur as we evaluate important information within the acquisition process.



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Five Steps in the T&E Process

STEP	DESCRIPTION
1	Identify critical issues and data requirements.
2	Pre-test engineering analysis by the evaluation and the development of an evaluation plan. Expected outcomes are predicted.
3	The test is planned and conducted. Data are retrieved and analyzed. Data may be collected from other means such as Modeling and Simulation (M&S), training, etc.
4	A post-synthesis step in which an evaluation report of data is compiled. Predictions from Step 2 are compared with actual measured outcomes.
5	T&E results are balanced with other available program information. The appropriate programming decision is made.

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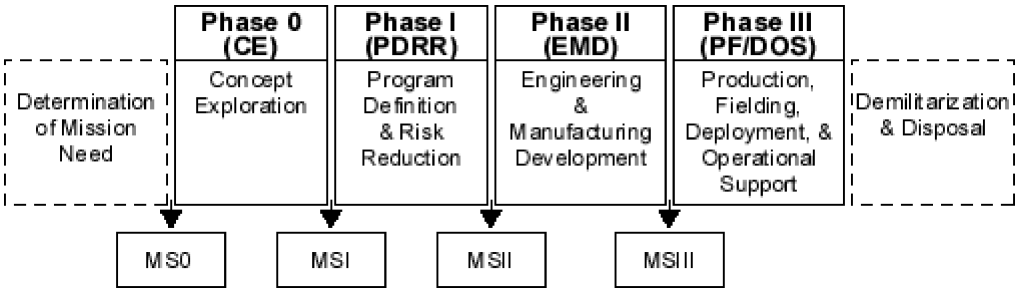
T&E and the Acquisition Life Cycle

T&E activities occur throughout the acquisition life cycle. T&E results are required during each phase to support the next milestone decision.



Milestone 0 Review

Key Milestone 0 Review Activities:

- Need is validated and reviewed.
- Authorization is granted to proceed to Phase 0.
- Exit criteria for Phase 0 are determined.

In support of Milestone 0, T&E personnel may supplement battle labs and experimental programs to determine program warfighting requirements; however, no actual system testing occurs before Milestone 0 review. Early T&E begins in Phase 0.

Milestone I Review

Key Milestone I Review Activities:

- Analysis of Alternatives is reviewed.
- Most promising systems concepts are selected.
- New acquisition program is authorized.
- Exit criteria for Phase I are determined.

In support of Milestone I during Phase 0, T&E personnel:

- Determine the testability of the exit criteria.
- Develop a Test and Evaluation Master Plan (TEMP), which will include a top-level T&E strategy and identify major test objectives, test events, simulations, resources, and timing.
- Confirm that Phase 0 exit criteria relative to T&E are met.
- Assist the program office in evaluating top-level system digital models that will be used and refined throughout system development.

Milestone II Review

Key Milestone II Review Activity:

- Decision is made to enter into full-rate production.

In support of Milestone II during Phase I, T&E personnel provide data confirming that:

- Performance of system components and overall design satisfy mission requirements.
- Performance meets Phase I exit criteria.
- Performance of early prototypes and engineering development models is validated.
- System models are verified and validated.
- Virtual prototypes accurately represent system performance.

Milestone III Review

Key Milestone III Review Activities:

- Decision is made to proceed with full-scale engineering and manufacturing development.
- Most promising systems concepts are selected.

In support of Milestone III during Phase II, T&E personnel:

- Collect critical data on the effectiveness, suitability, and survivability of the system.
- Analyze data and provide decision makers with information to help them decide whether to produce and deploy the system.
- Evaluate Phase II exit criteria.
- Complete Live Fire and Initial Operational T&E.
- Refine and validate Modeling and Simulation (M&S) tools with test data from prototypes.

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Developmental T&E (DT&E)

DT&E is conducted throughout the life cycle to:

- Identify potential operational and technological capabilities and limitations of alternative design concepts and options.
- Support identification of cost-performance trade-offs.
- Support identification and description of design technical risks.
- Assess progress toward meeting critical technical parameters.
- Provide data and analysis to support the decision to certify the system is safe and ready for operational T&E.
- Assist the program office in finding fixes to performance problems.

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Operational T&E (OT&E)

OT&E are field tests conducted under realistic operational conditions of any item (or key component) of weapons, equipment, or munitions to:

- Determine the effectiveness and suitability of the systems for use in combat by typical military users.
- Provide decision makers with an evaluation of such test results.

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Contrasting DT&E Versus OT&E

	DT&E	OT&E
What is Tested?	Measures technical performance against the design specifications in a controlled environment.	Determines operational effectiveness and suitability as defined in the Operational Requirements Document (ORD).
Who Conducts Test?	Government and contractor	Government
Who is Responsible?	Program Manager	Independent Operational Testing Agency (OTA)

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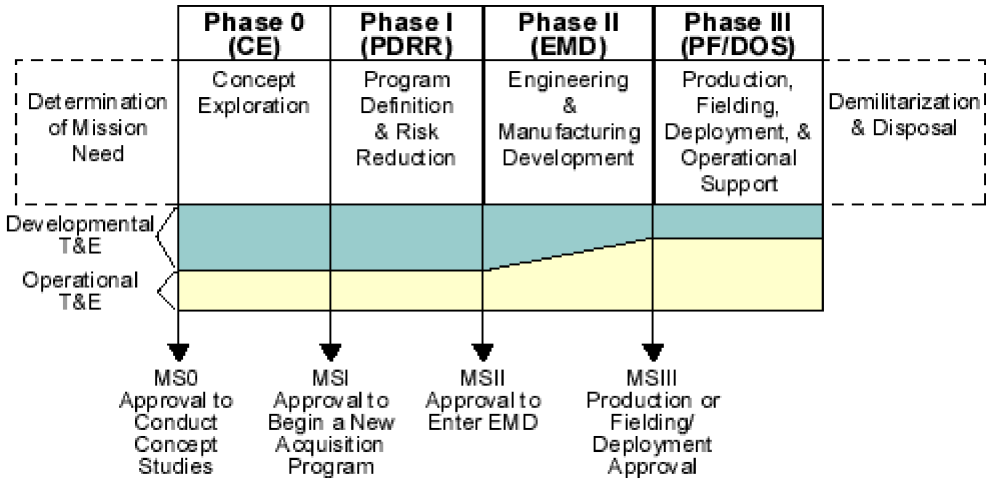
Types of Testing and the Life Cycle

T&E is continuous throughout the life cycle with early emphasis on DT&E. Later, emphasis shifts to OT&E as the system design becomes more stable. Both types of testing can occur throughout the life cycle.



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A Closer Look at DT&E

DT&E has the following major purposes:

- Serves as a feedback loop within the Systems Engineering Process.
- Identifies and mitigates technical design risks.
- Measures technical performance (thresholds and objectives) and contract specification compliance.
- Updates and validates models and simulations.

Performance and Environmental Factors

DT&E assesses performance under a number of environmental parameters. Listed below are examples of performance factors and environmental factors considered during DT&E.

Performance:

- Accuracy
- Maneuverability
- Interoperability
- Material Strength
- Reliability
- Maintainability
- Software Integration
- Software Functionality

Environmental:

- Temperature
- Pressure
- Vibration
- Shock
- Humidity
- Sea Salt Spray
- Rain, Snow, Ice
- Lightning

DT&E Requirements

In the DT&E requirements generation process:

- The Government establishes requirements using such documents as the:
  - Operational Requirements Document (ORD),
  - System Threat Analysis (STA),
  - Test and Evaluation Master Plan (TEMP), and
  - Analysis of Alternatives (AoA).
- DT&E requirements are communicated to contractors through such contract documents as the:
  - Statement of Work (SOW),
  - Statement of Objectives (SOO),
  - System Specifications, and
  - Work Breakdown Structure (WBS).
- The contractor establishes subsystem DT&E requirements and communicates them to each subcontractor.

Contractor's Role in DT&E

The contractor:

- Develops and delivers, for Government approval, an Integrated Test Plan (ITP), when required by the PM.
- Conducts sufficient testing before delivery to the Government.
- Provides technical support to Government T&E personnel.
- Corrects deficiencies discovered through testing.
- Helps to minimize testing redundancy.

Special Types of DT&E

Two specific types of DT&E are Production Acceptance T&E (PAT&E) and Live Fire T&E (LFT&E). Production Acceptance T&E is used to verify that each production unit meets contract requirements. It is usually conducted at the contractor's facility. The Defense Contract Management Command (DCMC) may provide oversight. Other Government personnel representing the developer and/or the user may also observe this testing. Live Fire T&E provides a realistic assessment of weapon platform/crew vulnerability and lethality of conventional munitions/missiles. LTF&E is required for all ACAT I and II programs or modifications that impact the system's vulnerability or lethality in combat. It is mandated by Congress, and funded by the program office. Results must be reported to Congress prior to a Milestone III Review decision.

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A Closer Look at Operational T&E

Purpose

Operational T&E (OT&E) assesses the system or components under realistic conditions to determine operational effectiveness and operational suitability.

Operational Effectiveness and Suitability

Operational effectiveness is the degree of mission accomplishment achieved when a system is used by representative personnel in the environment planned or expected for operational employment of the system. Factors taken into account to assess operational effectiveness include:

- Organizational Aspects
- Doctrine

- Tactics
- Survivability
- Vulnerability
- Threat

Operational suitability is the degree to which a system can be placed satisfactorily in field use. Factors taken into account to assess operational suitability include:

- Reliability
- Supportability and Maintainability
- Availability
- Compatibility
- Interoperability
- Safety
- Human Factors and Training
- Transportability
- Wartime Usage Rates
- Documentation

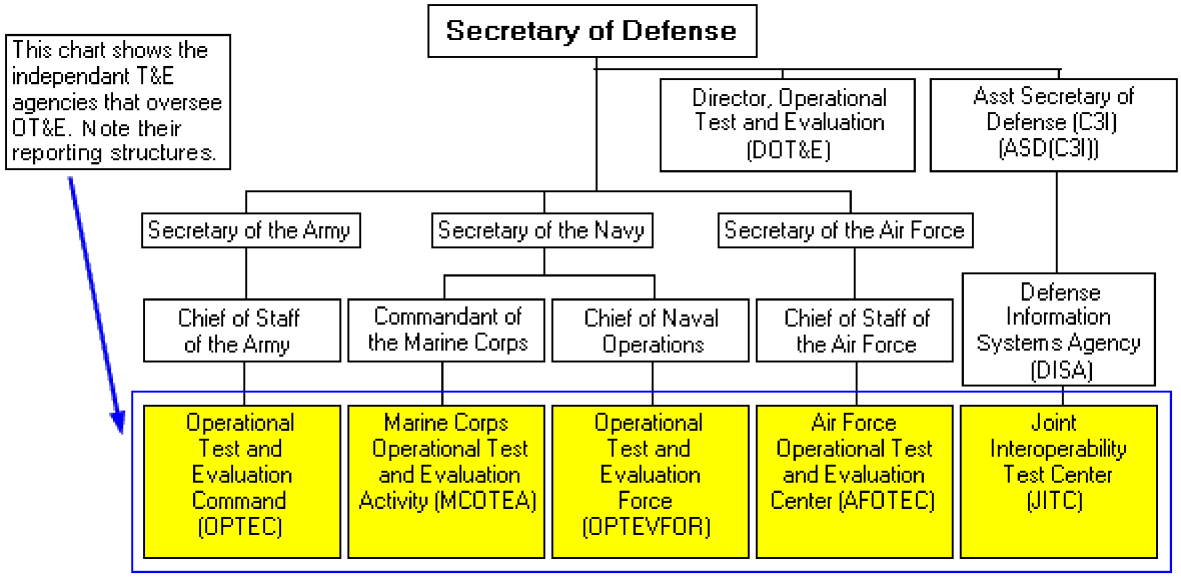
Importance of Independent T&E

While operational field personnel may perform OT&E activities under "typical" operational conditions, OT&E is overseen by an independent Operational Test Agency (OTA) within each service.

Independent assessment is critical to ensure objectivity in determining if operational performance effectiveness and suitability requirements specified in the ORD have been met.

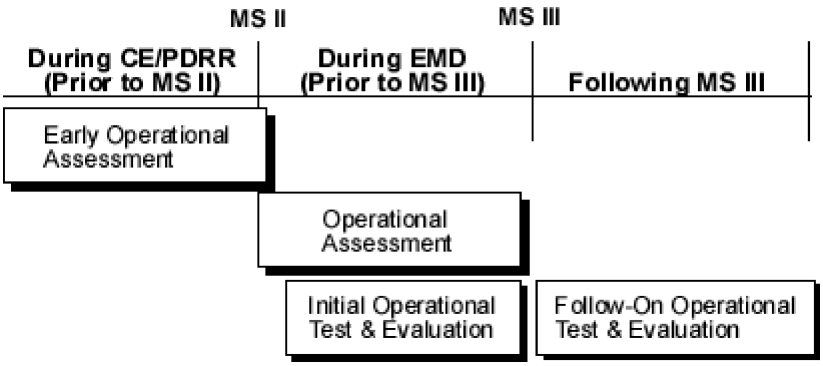
Independent Operational Test Agencies (OTAs)

The organizations in the shaded boxes oversee OT&E.



OT&E Process

The type of OT&E conducted depends on the maturity of the system design and acquisition strategy.



Type of OT&E Test	Description
Early Operational Assessment (EOA)	Performed on prototypes developed during the Program Definition and Risk Reduction (PDRR) phase to help decision makers assess the proposed concepts.
Operational Assessment (OA)	Conducted during the Engineering and Manufacturing Development (EMD) phase. Assesses the system's potential to meet mission requirements and supports a Low Rate Initial Production (LRIP) decision.
Initial Operational Test and Evaluation (IOT&E)	Conducted on production or production representative articles to support a Milestone III Review decision for entering into full-rate production and development.
Follow-On Operational Test and Evaluation (FOT&E)	Conducted after Milestone III Review and may continue throughout the life cycle. Confirms correction of deficiencies noted in IOT&E; develops tactics and doctrine for the new system; evaluates major modifications and/or changes to the system.

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T&E Planning

Importance of T&E

T&E can be expensive and sometimes dangerous, so extensive planning is required. Typical T&E planning activities include:

- Determining types and quantity of data to be collected.
- Estimating the anticipated test risks/results through simulation and modeling.
- Establishing safe test procedures.
- Ensuring environmental protections are in place.
- Projecting resource and schedule requirements.

T&E Planning and Teamwork

T&E information helps the IPT make a variety of decisions, including:

- Planning Decisions: What T&E should be performed?
- Management Decisions: Is the system ready for production?
- Design Decisions: How can we improve performance?
- Contractual Decisions: Does it work as specified?
- Logistical decisions: What types of operator training are needed?

T&E activities can affect IPT members' work schedules and resources. Therefore, T&E planning must involve all IPT members.

Test and Evaluation Master Plan (TEMP)

The Test and Evaluation Master Plan (TEMP) provides an overall test management plan and framework within which detailed T&E plans are contained. DOD 5000.2-R requires that a TEMP be produced for all ACAT I and IA programs and other programs designated for OSD test and evaluation oversight. While TEMPs are not required for other programs, the TEMP format and procedures can be used at the discretion of the Milestone Decision Authority on these programs.

TEMP Requirements

The TEMP must:

- Integrate T&E with the overall acquisition strategy.
- Reflect the user's requirements, and describe how these requirements will be tested in DT&E and OT&E.
- Document the T&E program for the entire life cycle.
- Specify personnel, funding, and test range support requirements.
- Be developed prior to Milestone I Review and updated before each subsequent Milestone Review.

TEMP Source Documents

For developing a TEMP, T&E personnel use such validated and approved requirements documents as the:

- **Mission Need Statement (MNS)**

  The Mission Need Statement identifies the overall requirement or threat, and the need for a materiel solution to address the requirement. T&E personnel use the MNS to determine the overall need and to assess what general types of tests and test resources will be needed during the T&E activities. T&E personnel must also be aware of changes in the ongoing nature of the threat or deficiency to determine if the user need has changed during the time the system is under development.

- **Operational Requirements Document (ORD)**

  The Operational Requirements Document describes the system solution selected to meet the mission need. The ORD is an important resource for T&E personnel. Because the ORD is a definitive statement of the user need, it serves as a primary source of operational testing requirements.

  The critical user needs are expressed in terms of minimum acceptable operational performance requirements, which are described with both threshold and objective values. The T&E community will be asked to test and evaluate whether the threshold values are being met, and also determine the feasibility of enhancing performance up to the objective values.

The ORD is also the source of some key program schedule parameters, including the date of initial operational capability (IOC) and the date of full operational capability (FOC). The IOC date defines the length of the development program, which will affect the size and extent of the test program.

- **System Threat Analysis (STA)**

  The Systems Threat Analysis describes the threat to be countered and the projected threat environment. T&E personnel must also be aware of changes in the ongoing nature of the threat to determine whether the system operates effectively within the projected threat environment.

- **Acquisition Program Baseline (APB)**

  The Acquisition Program Baseline specifies system performance, cost, and schedule requirements that must be met to ensure the acquisition program remains on track. The APB provides key technical performance parameters that the system is required to attain. T&E personnel developing a TEMP can use the APB parameters as the most definitive statement of the system performance requirements.

- **Analysis of Alternatives (AoA)**

  The Analysis of Alternatives evaluates a range of proposed approaches to satisfy the mission need. T&E personnel use the system performance requirements stated within the AoAs as a basis for selection of the T&E activities. The system performance requirements stated as functional objectives are broken down into measures of effectiveness, suitability, and performance. T&E personnel use these measures to identify what elements can be evaluated, and select the specific tests required to demonstrate the required system performance. TEMP developers must review these specific performance parameters to determine whether they are accurate and whether they can be evaluated.

TEMP Contents

The mandatory TEMP format includes:

- **Part I - System Introduction**

  The System Introduction section provides an overview description of the system, describing what it is, what it is supposed to do, and key areas for testers to concentrate on.

- **Part II - Integrated Test Program Summary**

  The Integrated Test Program Summary provides an overview of the T&E program and schedule. This summary includes two sections. The Integrated Test Program Schedule is a timeline depicting the sequence of the critical test and evaluation phases and events, and the program milestones they support. The Management Section describes the responsibility of all participating organizations within the T&E program.

- **Part III - Developmental Test and Evaluation Outline**

  This section provides an overview-level description of the proposed Developmental Test and Evaluation (DT&E) activities. This includes both the DT&E Overview and Future DT&E sections. The DT&E Overview explains how DT&E will verify the status of the engineering design and development process, verify design risks have been minimized, substantiate achievement of contract technical performance requirements, and be used to certify readiness for dedicated operational testing. The Future DT&E section discusses all remaining DT&E that is planned.

- **Part IV - Operational Test and Evaluation Outline**

  The Operational Test and Evaluation Outline is usually written by the service independent

Operational Test Agency (OTA).

- **Part V - Test and Evaluation Resource Summary**

  The Test and Evaluation Resource Summary lists all key test and evaluation resources, both Government and contractor, that will be used during the course of the test program. Any resource shortfalls that may result in significant test limitations are identified, along with planned corrective actions.

The estimates within the preliminary TEMP are updated and revised throughout the acquisition life cycle to reflect any changes in system concept, resource requirements, or threat assessments.

Unique TEMP Terms

Term	Definition
Critical Operational Issues (COIs)	Top-level issues that must be examined in OT&E to determine the systems capability to perform its mission. COIs are included in Part IV of the TEMP. COIs are categorized in terms of effectiveness and suitability.
Critical Technical Parameters (CTPs)	Engineering design factors that a system must meet or exceed to ensure that established performance thresholds are achieved. They are derived from the ORD, critical system characteristics, and systems engineering documents. CTPs are listed in a matrix, along with the performance objectives and thresholds in Part I of the TEMP.
Measures of Effectiveness and Suitability (MOEs & MOSs)	Performance capabilities and characteristics identified in the ORD and AoA. They appear in Part I of the TEMP and are used to determine the attainment of the top-level performance issues.

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REVIEW RESOURCES

Lesson 20: Acquisition Logistics: Fundamentals

Overview

Acquisition Logistics is a multi-functional technical management discipline associated with the design, development, testing, production, fielding, sustainment, and improvement/modification of cost-effective systems that achieve the user's peacetime and wartime readiness requirements.

To ensure that new systems are adequately supported, acquisition logisticians ensure that the system is designed for supportability, or consider supportability as a selection criteria for off-the-shelf purchases. They also design the support infrastructure, and make sure that all the necessary support structure is in place when the system is fielded.

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Supportability

Supportability is the degree to which system design characteristics and planned logistics resources meet system peacetime readiness and wartime utilization requirements.

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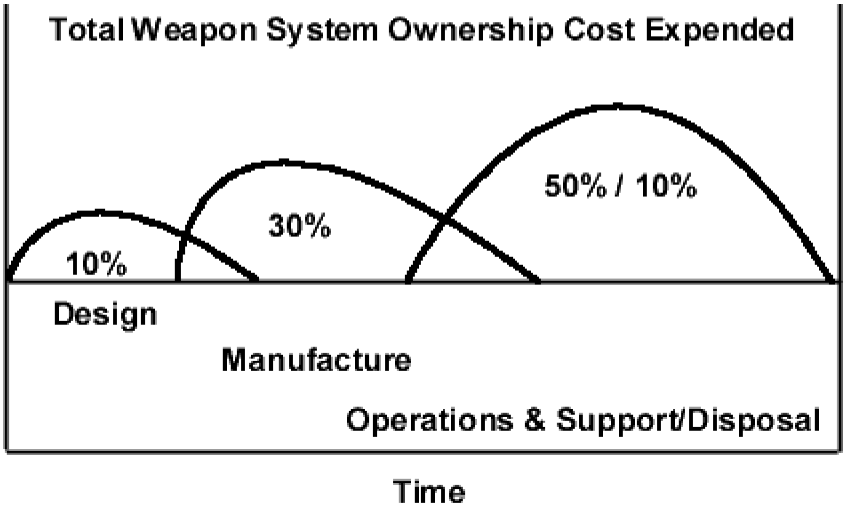
System Cost Over Time

As indicated in the chart below, more than 60 percent of the life cycle cost of a system occurs during the operations and support and disposal phases of the system life cycle. The decisions which have the most impact on the operations and support costs are made early during system design and development. Therefore, it is essential that supportability be a key element during these decisions.



LIFE CYCLE COST

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Minimizing Support Costs

Support costs can be reduced by using:

- Supportability considerations to address the upfront design process as a part of the overall Systems Engineering effort.
- Systems engineering practices to improve reliability, availability, and maintainability.
- Integrated Product and Process Development (IPPD).

Actions to reduce support costs should be taken early in the acquisition life cycle.

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Life Cycle Cost

Life cycle cost (LCC) includes the cost to develop, acquire, maintain, and dispose of a weapon system over its entire life. LCC includes system:

- Research, development, test, and evaluation
- Investment (procurement)
- Operations and Support
- Disposal

LCC also includes:

- Operators and maintenance personnel
- Spare parts
- Support equipment
- Facilities that will be needed for training, storage, and maintenance

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Supportability as a Key Factor

After requiring contract specifications to include reliability and maintainability requirements, the Navy's F/A-18 was **twice as reliable** as other Navy warplanes and required **less than half** the maintenance.

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Supportability Goals

The goal of supportability is to increase system capability while:

- Reducing ownership costs.
- Reducing dependence on spares.
- Requiring fewer support personnel.

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Reliability

Reliability is the probability that an item can perform its intended function for a specified interval under the stated conditions. ("How long will it work?")

Mean Time Between Failures (MTBF) is the average time interval between failures for repairable equipment.

One way to view system reliability is by calculating Mean Time Between Failures (MTBF). MTBF is the amount of time between one failure, its correction, and the onset of a second failure of the same component or subassembly--based on the entire population of equipment. MTBF is usually provided in units of operating hours or other measures, such as time, cycles, miles, or events.

For example, if a subsystem, such as a flight control subsystem, operates for 100,000 hours with one failure and there are 100 similarly reliable subsystems in use, the overall MTBF equals

$$\frac{100{,}000}{100}$$ or 1,000 hours.

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Maintainability

Maintainability is the measure of an item's ability to be retained in or restored to a specified condition when maintenance is performed by skilled personnel, using the correct procedures and resources. ("How long does it take to repair?")

Maintainability describes the ease, accuracy, and economy of performing a maintenance action. Maintainability results from system design, which should include (to the maximum extent possible):

- Accessible parts.
- Requirements for standard repair parts and tools.
- Interchangeable components.
- Throw-away replacement modules.

Mean Time to Repair (MTTR) is used to measure maintainability. MTTR is calculated as follows:

$$\text{MTTR} = \frac{\text{Total Elapsed Time}}{\text{Total Number of Corrective Maintenance Actions within a Given Time Period}}$$

For example, if the total elapsed time (in clock hours) for corrective maintenance is 1,200 hours and

there are 60 maintenance actions completed in that timeframe, then MTTR equals 1,200/60, or 20 hours.

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Availability

Reliability and maintainability combine to form the most common measure of system effectiveness—availability.

Availability is a measure of the degree to which an item is in the operable and commitable state at the start of a mission when the mission is called for at an unknown (random) time. ("How ready is the system to perform when needed?")

The mathematical equation that represents availability is:

$$\text{Availability} = \frac{\text{Up Time}}{\text{Up Time + Down Time}}$$

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Supportability Objectives

DOD pursues three supportability objectives:

- Ensure cost-effective support.
- Provide the necessary infrastructure.
- Meet readiness requirements.

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Reliability, Availability, and Maintainability and Supportability

Reliability, availability, and maintainability are aspects of supportability. Supportability is the ability of a system's design to meet an operational need:

- Throughout its intended life.
- At affordable costs.

Acquisition logisticians use Reliability and Maintainability (R&M) data to formulate system support requirements. Critical points to remember include:

- A system's R&M characteristics are key drivers of support resources.
- R&M does not drive all operations and support costs (e.g., fuel costs).

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Support Considerations

Support considerations during system acquisition are ultimately the responsibility of the PM and

involve:

- Developing support concepts.
- Providing support data.
- Acquiring support resources.
- Conducting supportability analyses as a part of the Systems Engineering Process.

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Supportability Analyses

Supportability analyses are conducted as part of the Systems Engineering Process. The goals of supportability analyses are to ensure that:

- Supportability is included as a system performance requirement.
- The system is concurrently developed or acquired with the optimal support system and infrastructure.

For example, all of the following can be categorized as supportability analyses:

- Repair level analysis
- Reliability predictions
- Reliability-centered maintenance (RCM) analysis
- Failure modes, effects, and criticality analysis (FMECA)
- Life cycle cost analysis

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Supportability Concepts

Supportability concepts, also known as maintenance concepts, include where and how a system will be maintained. Supportability concepts drive many of the other support considerations.

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Support Data

Support data include items such as user's manuals, tools lists, and provisioning requirements. Acquisition logisticians must ask:

- What format will they be in?
- What training documentation is needed?
- What media will be used?

Support data requirements shall be consistent with the planned support concept and represent the minimum essential to effectively support the fielded system.

Government requirements for contractor-developed support data shall be coordinated with the data requirements of other program functional specialities to minimize data redundancies and inconsistencies.

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Support Resources

Support resources include the funding necessary to design and purchase the support. Funding requirements must be identified early so that the support structure is in place when the new system is deployed.

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Lesson 21: Acquisition Logistics: Supportability Planning

Support Elements

Every Acquisition program, regardless of size, must plan for 10 logistics support elements:

1. Maintenance Planning
2. Manpower and Personnel
3. Supply Support
4. Training and Training Devices
5. Support Equipment
6. Packaging, Handling, Storage, and Transportation
7. Facilities
8. Computer Resource Support
9. Technical Data
10. Design Interface

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Maintenance Planning

The purpose of maintenance is to ensure that the system can be maintained effectively and economically at the desired level of readiness after it is placed in operational use. Maintenance planning ensures that all required maintenance assets are placed to support deployment.

Maintenance planning specifies when, where, and how maintenace tasks will be performed on the system, including both:

- Preventative maintenance
- Repairs

The military historically has three levels of maintenance:

- Organizational – Personnel from the using unit make the repair.
- Intermediate – The repair is completed at a facility in the fleet or field.
- Depot – The repair is made at a major facility for repair by contractor or Government civilian personnel.

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Manpower and Personnel

Manpower and personnel are the "spaces and faces" support element of acquisition logistics. This element involves the identification and programming:

- For military and civilian personnel

- With skills and grades required to operate and support the system
- Over its entire life cycle
- In peacetime and war

Manpower refers to spaces (billets)–the number of people required for the mission. Manpower planning is resource driven and must be considered in the Planning, Programming, and Budgeting System (PPBS) process.

Personnel refers to faces–actual assigned people–civilians, officers, and enlisted personnel. Personnel must meet certain education, training, skill, and other administrative requirements.

Together, manpower and personnel are the highest life cycle cost drivers.

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Supply Support

Supply support means having the right part in the right place at the right time in the right quantity at the most economical cost.

Spare parts, or spares, are components or assemblies used for maintenance replacement purposes in major items of equipment. Spare parts may be classified into:

- Repair parts
- Consumable items

Item	Description
Repair Parts	Components, modules, assemblies, or subassemblies that can be restored to like-original condition when they become unserviceable. Some examples of repair parts include: circuit boards, radios, modular components, electronic display modules, and "black boxes."
Consumable Items	Also known as consumables, are parts or items that are consumed in use and are not intended for repair. Examples of consumable items are items used to repair repairables (e.g., nuts, bolts, washers, and cleaners).

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Training and Training Devices

Training and training devices include the processes, procedures, techniques, and equipment used to train civilian and military personnel to operate and support the system. This includes:

- Individual and crew training (initial and continuation).
- New equipment training.
- Initial, formal, on-the-job, or embedded training.

The quality, quantity, and timing of training must be integrated with personnel and deployment planning to ensure that the system can be operated and maintained effectively from the start.

Training types include: traditional classroom, computer-based training, distance learning, and self-instruction.

Training may be located: at a school, on site in a classroom, on the job using system equipment or simulators, or embedded in the system itself.

Training devices include: simulators, as well as special facilities, equipment, or personnel required to perform the training.

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Support Equipment

Support Equipment encompasses all equipment required to perform system operation and maintenance. This includes associated:

- Multi-use end items (e.g., generators, hydraulic jacks, etc.).
- Ground handling and maintenance equipment.
- Tools.
- Organizational, field, and depot support equipment (e.g., electronic test equipment, cranes, lift trucks, lathes and other machine shop equipment, etc.).
- Metrology and calibration equipment.
- Test equipment.
- Automatic Test Equipment (ATE), which includes:
  - Hardware and operating system software.
  - Test program sets that include the interface test adapter hardware and software programs to test individual weapon electronic items.
  - Associated software development environments and interfaces.
- Related computer programs.

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Packaging, Handling, Storage, and Transportation

Packaging, Handling, Storage, and Transportation (PHST) includes the resources, processes, procedures, design considerations, and methods to ensure that the system, equipment, and support items are properly packaged and preserved, handled, stored, and transported.

PHST includes:

- Containers and packing materials.
- Forklift trucks.
- Cargo ships and aircraft, including commercial transport.
- Dock workers.
- Transportation schedules and other paperwork.
- Warehouses, including warehouse security measures.
- Measures taken to preserve the condition of the items.

Key emphasis is on the avoidance of damage or deterioration in safe and timely movement and storage of systems. New systems should be designed to utilize standard DOD transport equipment. A certificate of transportability must be obtained by system Program Managers to ensure the system meets DOD transportability requirements for weight, cube, and overall dimensions.

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Facilities

Facilities constitute all permanent or semi-permanent real property assets required to support a system, including major modification of existing structures.

Systems design should strive to minimize or eliminate the facilities required to operate and support a defense system. Where facilities are demonstrated to be absolutely needed, maximizing the use of existing facilities should be considered.

Facilities must be considered very early in the acquisition process because, if Military Construction (MILCON) funding is necessary, the lead time for funding may be from 4 to 7 years.

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Computer Resource Support

Hardware and software are critical for operating most major weapons systems. Computer resource support includes the facilities, hardware, software, documentation, and people needed to operate and support embedded computer systems.

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Technical Data

Technical data are scientific information (recorded in any form or medium) necessary to operate and/or maintain a defense system. Data requirements should be consistent with the planned support concept and represent the minimum essential required to support the fielded system effectively.

Technical Data Package

Technical data are used to provide sufficient information to manufacture and support the system after deployment. When combined, this information is called the Technical Data Package (TDP) and may include:

- Engineering drawings and specifications.
- Process descriptions.
- Other documents that define the physical dimensions, materials composition, performance characteristics, manufacture, assembly, and acceptance test procedures for producing and/or supporting the system.

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Design Interface

Design interface is one of the traditional elements of logistics support and one critical function of logistics. The design interface ensures that there is a relationship between the design parameters such as reliability and maintainability, and readiness and support requirements. For example, the acquisition logistician would ensure that the design interface for a UHF antenna allows for easy mounting and maintenance of the item on an M-1 tank.

The early focus should result in the establishment of support-related design parameters. These parameters should:

- Be expressed both quantitatively (e.g., Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR)) and qualitatively (e.g., human factors) in operational terms.
- Relate specifically to systems readiness objectives and the support costs of the system.

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Support Planning

Program plans, excluding the Test and Evaluation Master Plan (TEMP), are not required in support of milestone decisions and shall not be used as milestone documentation or periodic reports. The acquisition logistician is usually responsible for planning program logistics support. Although logistics support plans are typically documented in a form acceptable to the Program Executive Officer/Program Manager (PEO/PM), a specific, formal formatted plan for support is not required.

Support Planning and Systems Engineering

Support planning is critical to the Systems Engineering Process. Its goal is to provide supportability information early on so that critical factors can be considered during Systems Engineering.

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REVIEW RESOURCES

Lesson 22: Software Acquisition: Fundamentals

Hardware and Software Basics

Before discussing software acquisition management, it is important to make sure that you have a working knowledge of some basic terms and concepts. This section reviews computer hardware and software basics.

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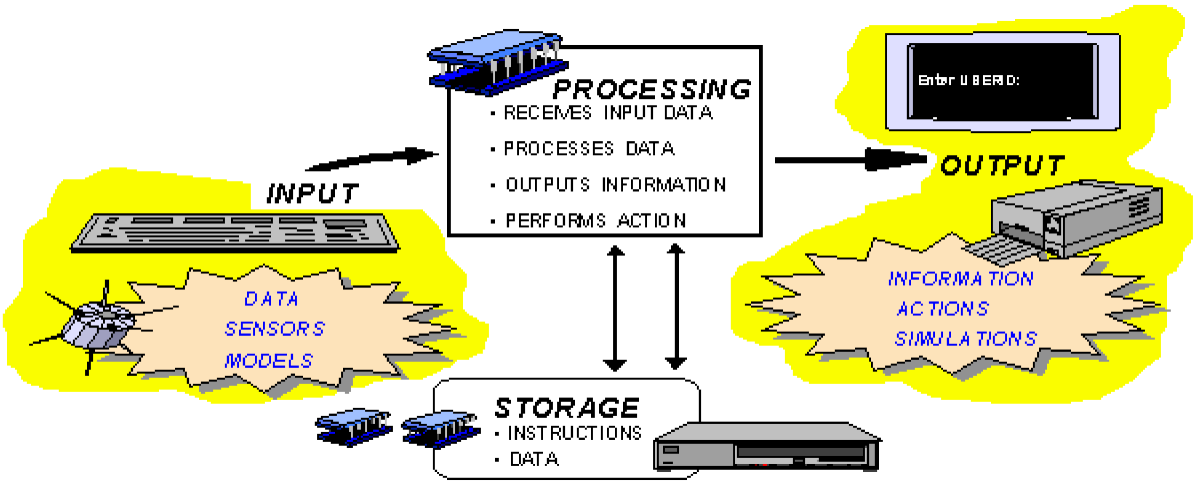
Hardware Overview

Systems with a high percentage of software functionality include the following four hardware elements: Input, Processing, Storage, and Output. These elements are shown below as part of a PC.



Input Device

A device whose purpose is to allow the user to enter information into a computer system. Common examples include keyboards, mice, and joysticks.

Processing Unit

The processing unit of a computer is the device that interprets and executes instructions. Processing is the vital step between receiving data (input) and producing results (outputs). A central processing unit or CPU is the brain of the computer.

Output Device

An output device makes the processing results (or data) accessible to the user. Common outputs include displays on the computer screen/panels, printed pages, sounds, or files to be stored/sent to another computer.

Storage Media

The various types of physical materials on which data are written and stored. Common storage media include floppy disks, hard drives, tape, and CD-ROMs.

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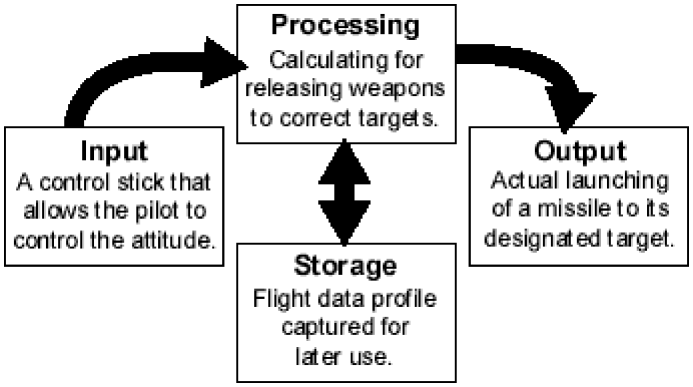
Hardware Elements and Defense Systems

The four hardware elements below appear in many DOD defense systems.



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Software Categories

Software contains the instructions that make the hardware work. Four categories of software are shown below.

- Operating Systems
- Application Software
- Network Software
- Programming Languages

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Operating Systems

Operating systems are the software that controls the allocation and usage of hardware resources such as memory, central processing unit (CPU) time, disk space, and peripheral devices. The operating system is the foundation upon which all other software running in the computer depends.

Popular operating systems include: Windows 95, Windows NT, Mac OS, and UNIX.

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Application Software

Application software performs a specific task, such as word processing, accounting, database management, or inventory control.

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Network Software

Network software permits the connection to or participation in a computer network. This type of software works closely with a computer's operating system.

Note: A network is defined as a group of computers and associated devices that are connected by communications infrastructure (cables, telephone connections, or other links).

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Programming Languages

Programming languages allow programmers to generate the code (or sequence of instructions) that tells the computer system what outputs to produce given certain inputs. All software (operating systems, application software, network software) is written using some type of programming language.

Software code instructs the system what outputs to produce, given certain inputs. This code is expressed in a programming language. Common languages that you may encounter in a defense system are:

- Machine Language
- Assembly Language
- Higher Order Language (HOL)
- Fourth Generation Language (4GL)

Machine Language

Machine Language is:

- The only language the computer speaks.
- Called binary code because the instructions are written either as zero or one. The binary statements control the computer's actions.
- Also referred to as object code.

An example of Machine Language:

Function: Adding two numbers

Machine Language Code:
0001 1100 1010 1111

Assembly Language

Assembly Language is:

- Written in abbreviations or using a mnemonic format. Each mnemonic statement corresponds to one machine language statement.
- Translated into machine language by a computer program called an "assembler."
- Used only for software that must be highly optimized (fast and/or compact).
- Is very hardware dependent.

An example of Assembly Code:

Function: Adding two numbers

Assembly Code:
LD A
ADD B
STR A

Higher Order Language (HOL)

Higher Order Language is:

- A general-purpose programming language that allows programs to be written without having to understand the inner workings of a computer.
- Translated, using a computer program called a "compiler," into a format (object code) executable by a computer.

Hundreds of different HOLs exist. Common HOLs include: Ada, BASIC, C, C++, COBOL, and FORTRAN.

An example of Higher Order Language:

Function: Adding two numbers

Ada Code:
C: = A + B;

Fourth Generation Language (4GL)

A Fourth Generation Language (4GL) is easier for nonprogrammers to use. These languages:

- Are oriented to very specific types of application domain (database access, report generation, etc.)
- Cannot handle as broad a range of applications when compared to HOLs.
- Can be much more productive than HOLs for very specific applications.

Example of a 4GL:

Function: Retrieve Data

Structure Query Language (SQL) Code:
SELECT TABLE 1

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What Is an Architecture?

An architecture can be defined as the structure of components, their relationships, and the principles and guidelines governing their design and evolution over time. In simple terms, an architecture is an in-depth blueprint for constructing and integrating all aspects of a software-intensive system. Following a well thought-out plan:

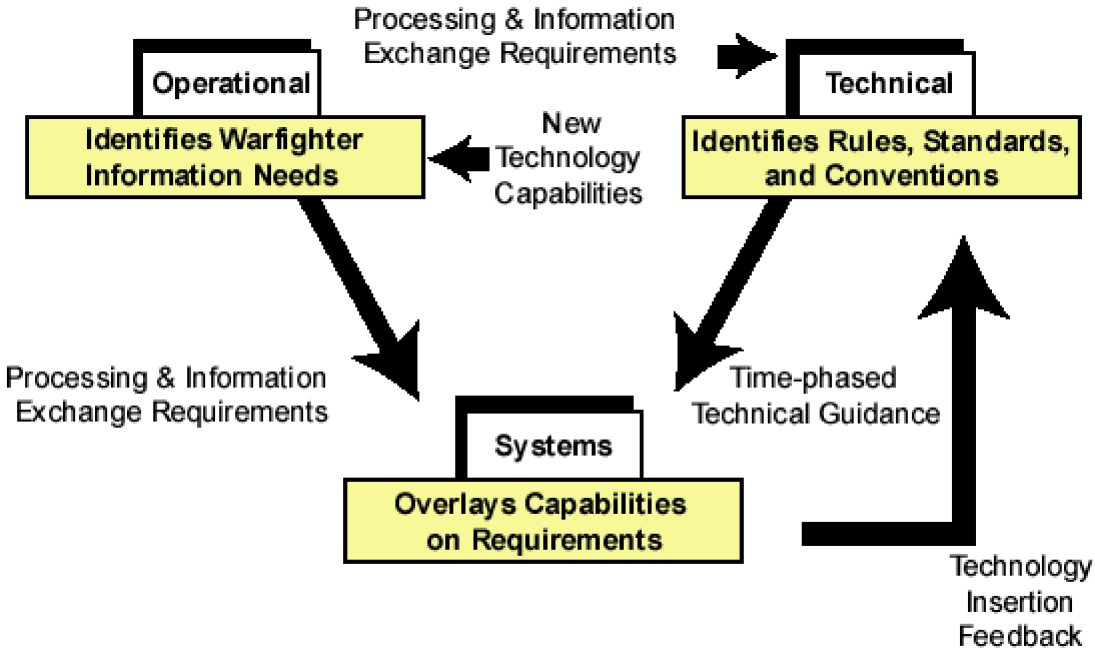
- Makes construction easier.
- Ensures compatibility between different systems or parts.

The Need for Architectures

Frequently, parts of the U.S. forces and allied military forces have to work closely together. Past experiences with joint operations have found that forging integrated international computer-communications networks can be extremely difficult.

Types of Architectures

DOD's Key Architectures



To address interoperability concerns, the DOD has defined an interrelated set of architectures that includes Operational, Systems, and Technical components. These architectures help ensure that U.S. forces and allied military forces can communicate during joint operations.

Operational Architecture

An Operational Architecture is a description of the operational elements, assigned tasks, and information flow required to accomplish or to support the warfighting function.

Technical Architecture

A Technical Architecture is the set of rules, or "building codes" that are used when a system engineer begins to design/specify a system to achieve interoperability.

These rules consist primarily of a common set of standards/protocols to be used for sending and

receiving information, for understanding the information, and for processing that information. This architecture also includes a common human-computer interface and "rules" for protecting the information.

Systems Architecture

A Systems Architecture is a description, including graphics, of systems and interconnections providing for or supporting warfighting functions. This type of architecture:

- Defines the physical connection, location, and identification of the key nodes, circuits, networks, warfighting platforms, etc.
- Specifies system and component performance parameters.
- Shows how multiple systems within a subject area link and interoperate.
- May describe the internal construction or operations of particular systems within the architecture.

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Joint Technical Architecture (JTA)

To foster interoperability, the DOD has adopted the use of the Joint Technical Architecture (JTA). JTA mandates the minimum set of standards and guidelines for the acquisition of all DOD systems that produce, use, or exchange information. These standards apply to:

- Information Processing
- Information Transfer
- Information Modeling
- Human-Computer Interfaces
- Information Systems Security

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What Is an Open System?

An Open System is another important concept that promotes interoperability among DOD systems. An Open System Architecture:

- Uses standards developed and agreed to in an "open" forum by all interested parties to define interfaces, services, and support formats.
- Allows applications to easily be used on different equipment.
- Helps to ensure that systems interact with users in a consistent way.
- Reduces development and training costs.
- Limits impact of hardware changes.
- Fosters the use and integration of commercial-off-the-shelf (COTS) software and hardware products.

Interoperability

Interoperability can be defined in many ways.

The DOD directive on interoperability (DODD 4630.5) defines it as:

> The ability of the systems, units, or forces to provide services to and accept services from other systems, units, or forces, and to use the services so exchanged to enable them to operate effectively together. Interoperability is the condition achieved between systems when information or services are exchanged directly and satisfactorily between

the system and/or their users.

Commercial-Off-The-Shelf (COTS)

Commercial items are those that require no unique Government modifications or maintenance over the life cycle of the product to meet the needs of the procuring agency. An example of a COTS software product is a commercial database management system (DBMS) used as part of a command, control, communications, computers, and intelligence (C4I) system.

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Importance of Software

Software touches nearly every facet of DOD systems. Some of the more common uses are inventory management and payroll. Less obvious software-intensive systems include aircraft and weapon systems.

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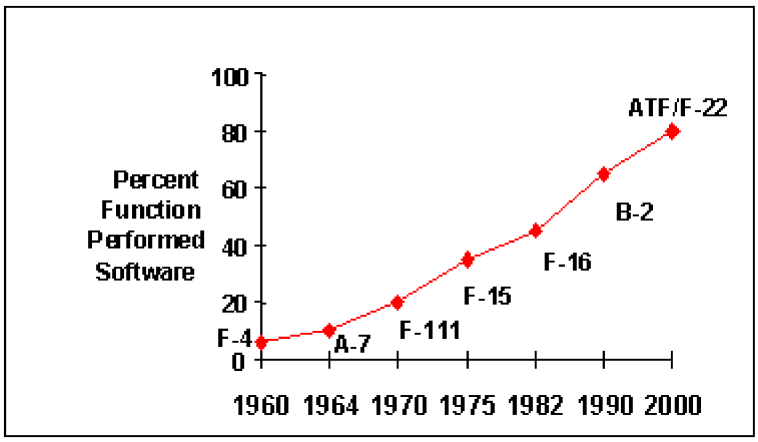
DOD Systems Software Dependencies



The role of software as the most critical part of weapon systems is growing.

For example, the F-22 Advanced Tactical Fighter is currently under development for the Air Force. Eighty percent of the F-22's functionality is dependent on software.

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Software-Intensive System: Definition

A Software-Intensive System is one in which software represents the largest segment in any one or more of the following criteria:

- System development cost
- System development risk
- System functionality
- Development time

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Types of Systems

There are three generic classifications of DOD software-intensive systems:

- Embedded
- Automated Information Systems (AIS)
- Command, Control, Communications, Computers, and Intelligence (C4I).

Embedded Systems

Embedded software is software that is specifically designed into (embedded) or physically integrated into a weapon system. This type of software performs highly specific functions such as weapons firing or navigation. The Patriot Missile or Mission Data Planning System for cruise missiles are examples of embedded systems.

Automated Information Systems (AIS)

Automated Information Systems are defined by the DOD as:

> A combination of computer hardware, software, data, or telecommunications that performs functions such as collecting, processing, transmitting, and displaying information. Excluded are computer resources, both hardware and software that are physically part of, dedicated to, or essential in real time to the mission performance of weapon systems.

Systems in this category may perform administrative functions such as: accounting, payroll, finance, personnel, inventory control, mapping, and equipment maintenance scheduling.

Command, Control, Communications, Computers, and Intelligence (C4I) Systems

C4I systems encompass command, control, communications, computers, and intelligence functions. C4I software is the component of a system that communicates, assimilates, coordinates, analyzes, interprets information, and provides decision support to military commanders.

C4I systems can be used at various levels:

- Strategic C4I systems at the highest levels of command. For example, planning a particular war scenario.
- Tactical C4I systems may be used by units in the field. For example, a field commander might receive target location information to execute a mission. The Global Command and Control System (GCCS) is such a C4I system.

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Common Issues

While each of these three categories of software-intensive systems share many common management and technical issues, there are some distinctions unique to each category. For example:

- Some laws and policies primarily apply only to AIS.
- Embedded software typically has higher development risks and quality requirements.
- C4I systems have stringent interoperability and security needs.

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Acquisition Categories

For acquisition purposes, software-intensive systems are categorized as follows:

Embedded and C4I Systems:

- ACAT I
- ACAT II
- ACAT III

AIS:

- ACAT IA
- ACAT III

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Brooks Act and Warner-Nunn Amendment

For more than 30 years, Federal Government Information Technology (IT) acquisitions, including those of DOD, were mandated by the provisions of the now obsolete 1965 Brooks Act and its 1982 Warner-Nunn amendment.

With the rapid changes in computer technology, the Brooks Act became obsolete. After a number of hearings and studies sponsored by Representative Clinger and Senator Cohen, the Information Technology Management Reform Act (ITMRA) (PL 104-106) was passed in 1996.

The Clinger-Cohen Act of 1996 incorporated the ITMRA and the Federal Acquisition Reform Act (FARA) into a single law.

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Key Thrusts of ITMRA Portion of the Clinger-Cohen Act

The Information Technology Management Reform Act (ITMRA) portion of the Clinger-Cohen Act of 1996 is substantially changing the way agencies acquire Information Technology (IT) within the Federal Government.

The key thrusts of ITMRA are to:

- Require greater accountability for systems improvements achieved through the use of IT.
- Implement performance-based and results-based management.

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Key Provisions of ITMRA (Clinger-Cohen Act)

- Defining terms such as IT and National Security Systems (NSS).
- Repealing the Brooks Act.
- Designating the Office of Management and Budget (OMB) as a focal point to promote IT management within the Federal Government.
- Identifying the Government Accounting Office (GAO) as a single agency protest forum.
- Designating a Chief Information Officer (CIO) for each executive agency.

- Encouraging the use of "Modular Contracting" for categories of systems.

Information Technology

IT is any equipment or interconnected system or subsystem of equipment, that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information. It includes computers, ancillary equipment, software, firmware and similar procedures, telecommunications and communications equipment, services (including support services), and related resources.

National Security Systems (NSS)

NSS are those systems that involve:

- Intelligence activities.
- Cryptologic activities.
- Command and Control of military forces.
- Equipment that is:
  - An integral part of a weapon system, or
  - Critical to the direct fulfillment of military or intelligence missions.

These categories of systems are exempt from some (but not all) of the provisions of the Clinger-Cohen Act.

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Chief Information Officer (CIO)

The designated Chief Information Officer must:

- Have information resources management duties as his or her primary job.
- Monitor and evaluate the performance of information technology programs and advise the agency head on whether to continue, modify, or terminate IT programs.
- Serve as the MDA for ACAT IAM programs.

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DOD Policy Guidelines

The DOD policies for planning computer resources are outlined in DOD 5000.2-R and DODD 5000.1. This section will give an overview of some important guidelines described in these documents.

DOD 5000.2-R

An important document for Software Acquisition Management guidance is the DOD 5000.2-R. This document states:

> "Software shall be managed and engineered using best processes and practices that are known to reduce cost, schedule, and performance risks. It is DOD policy to design and develop software systems based on systems engineering principles."

Software Engineering Policy Guidance

DOD 5000.2-R provides policy guidance for Software Engineering that includes:

- Developing software systems architectures that support open system concepts.
- Identifying and exploiting software reuse opportunities (before beginning new software development).
- Selecting programming languages in context with the systems and software engineering factors.
- Using DOD standard data elements.
- Exploiting the use of COTS products.
- Selecting contractors with:
    - Experience in the software domain (or product line).
    - Successful past performance records.
    - Demonstrable mature development capabilities and processes.
- Using a software measurement process to plan and track software programs.
- Assessing Information Operations risks.
- Ensuring software is Year 2000 (Y2K) compliant.

Architectures That Support Open Systems Concepts

This approach is a business and engineering strategy to use specification and standards that are adopted by industry standard bodies or are de facto standards (set by the marketplace) for selecting system interfaces (functional and physical), products, practices, and tools.

Software Reuse

Software reuse is the process of implementing or updating software systems using existing software assets. An example is reusing the Human-Computer Interface (HCI) software from one C4I system on another system rather than paying for the development of two separate interfaces.

DOD Standard Data Elements

Standardized data results from the process of documenting, reviewing, and approving unique names, definitions, and representations of a data element according to established procedures and conventions. (Source: DOD 8320.1)

Note: A data element is a named identifier of each of the entities and their attributes that are represented in a database.

DODD 5000.1

This directive provides additional guidance on software acquisition management by stating:

> "It is critical that software developers have a successful past performance record, experience in the software domain or product line—a mature software development process and evidence of use and adequate training in software methodologies, tools, and environments."

A variety of frameworks can be used to assess "process maturity."

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Software Capability Maturity Model (SW-CMM)

One commonly-used framework for assessing "process maturity" was developed by the Software Engineering Institute (SEI), a DOD agency. The SEI framework is called the Software Capability Maturity Model (SW-CMM). The SW-CMM requires certain key practices to be in place for developers to be assessed at a certain level of process maturity.

There are five levels to the SW-CMM:

- Initial
- Repeatable
- Defined
- Managed
- Optimizing

Initial Level

Organizations at the Initial Level are characterized by:

- Chaotic and ad hoc development.
- The lack of defined processes.
- Relying on heroics (the one "hot-shot" programmer staying up all night) to complete the project.

The majority of software developers are at a lower level.

Repeatable Level

Organizations reach the Repeatable Level when:

- Basic program management processes are established.
- They can repeat earlier success achieved on similar types of projects.

Defined Level

Organizations reach the Defined Level when:

- The processes for both engineering and management activities are documented, standardized, and integrated into a standard process for the organization.
- The organization can tailor standards for a particular project.

Managed Level

Organizations reach the Managed Level when:

- They are able to collect detailed measures of the software process and quality.
- The process and product are understood and controlled.

Optimizing Level

Organizations reach the Optimizing Level when they measure their processes and use these measurements to continuously improve their processes.

Very few software developers are rated at this high level.

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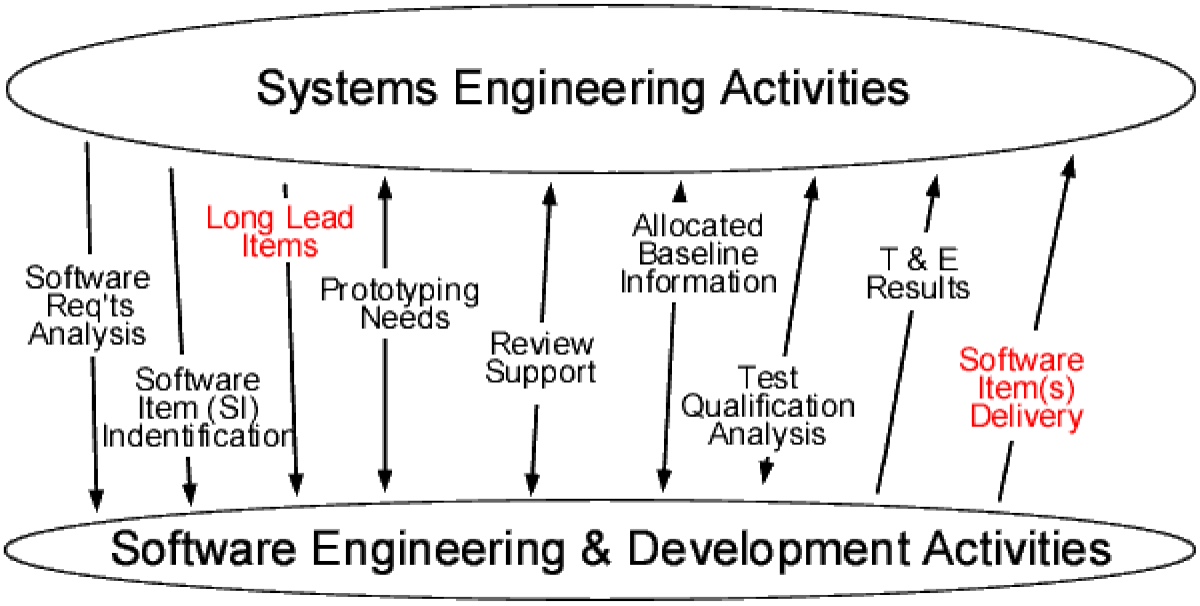
REVIEW RESOURCES

Lesson 23: Software Acquisition: Development and Management

The Linkage Between Systems Engineering and Software Development

The DOD policy is to design and develop software based on Systems Engineering principles. Some examples of the linkages based on these principles are shown below.



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Why Worry About Software?

Software is an integral part of most defense systems. Following are two reasons why software development requires special attention:

- Software development can be difficult to monitor because it is a complex, changeable, and invisible product.
- Once software development is late, adding more resources typically results in making the project even later.

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Software Risk Management

Most software development projects are very large and complex. Breaking a software-intensive project into more manageable parts helps the people involved better understand the tasks and resources

needed. By understanding the complexity of an effort, managers are better able to plan and manage the risk.

Software Items (SIs): The Building Blocks

As part of the Systems Engineering Process, the software is usually broken down into smaller building blocks called Software Items (SIs). After being developed and individually tested, Software Items are integrated with the hardware and ultimately the entire system.

A Software Item (SI) is a collection of software that performs closely related functions. Each SI is uniquely designated throughout the life cycle for purposes of:

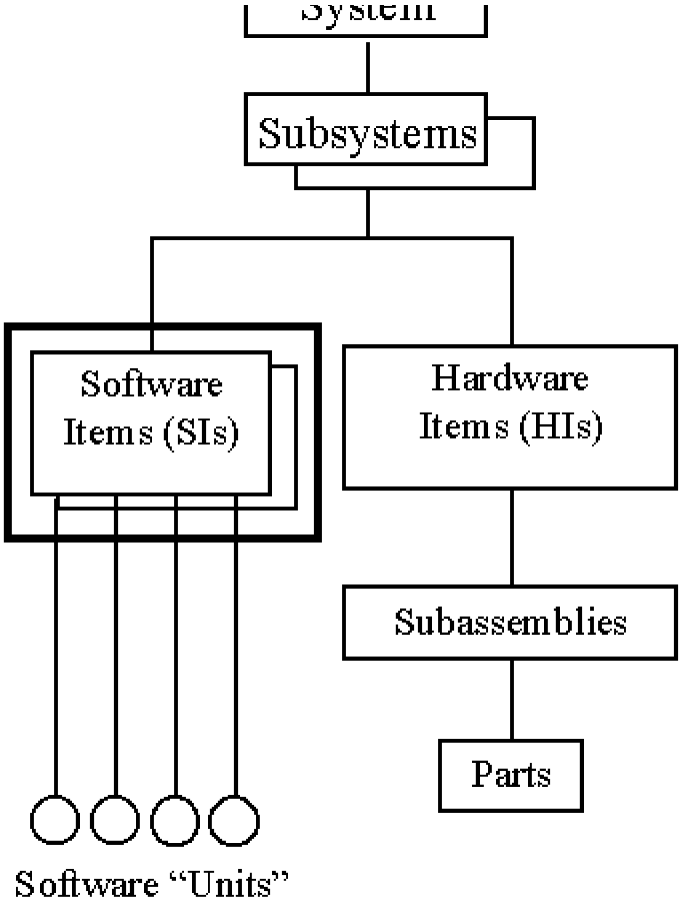
- Managing requirements.
- Conducting qualification testing.
- Controlling interfaces.
- Ensuring configuration management.
- Mitigating risk.

Note: In the past, Software Items were called Computer Software Configuration Items (CSCI).

SIs and Work Breakdown Structures

As you learned in a previous lesson, a Work Breakdown Structure (WBS) divides complex projects into pieces so that risks can be identified and managed.

As illustrated below, WBS can be used to organize the Software Items (SIs) and to show the relationship among the different system components.



Software Units

To facilitate programming, Software Items (SIs) can be broken down into smaller, logically related pieces. Many commercial standards call these pieces "Software Units."

Software Units include individual programs such as modules or routines that perform specific functions.

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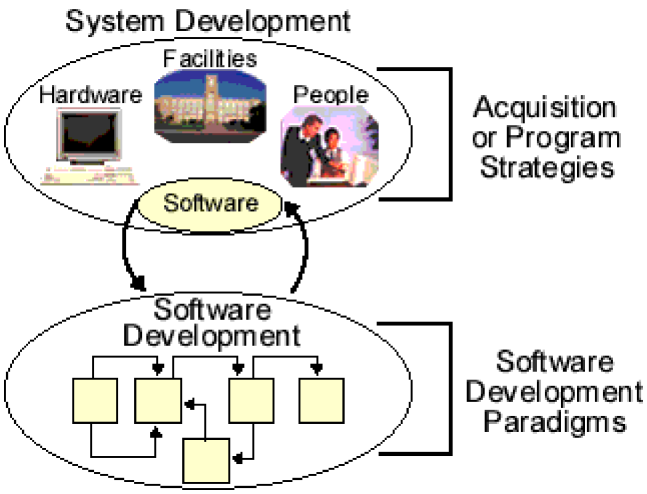
Development Paradigms

In an earlier lesson, you learned about the importance of structuring a tailored acquisition or program strategy.

The software developer uses a similar structured approach to lay out software development tasks. These different ways of laying out tasks are referred to as "software development paradigms."



What Are Paradigms?

In a software engineering context, the approaches to structuring software development are called "Software Development Paradigms." A more common word for paradigms is models.

Types of Paradigms (Models)

The three common software development models are called:

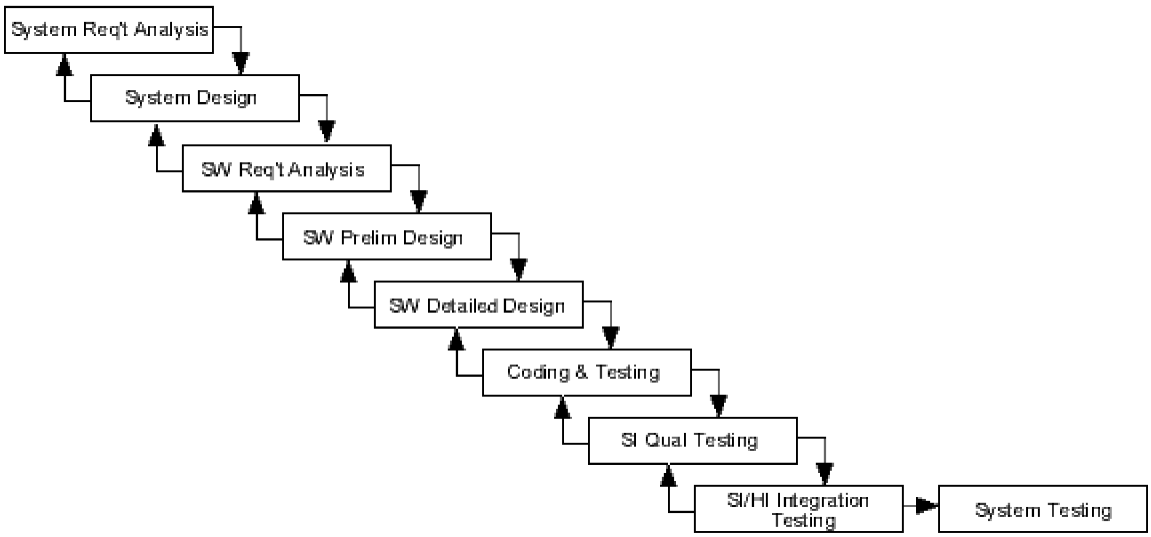
- Waterfall Paradigm
- Incremental Paradigm
- Spiral Model

Waterfall Paradigm

The Waterfall Paradigm is implemented using a sequential process. In the traditional Waterfall Paradigm:

- Each stage is a prerequisite for succeeding activities.
- Successful completion of a stage is required before starting the next one.
- Formal reviews are used to assess the completion of each stage.

As illustrated below, the developer must be able to accurately estimate the difficulty of all required steps. Therefore, the Waterfall Paradigm works best with a precedented software-intensive system.



Precedented System

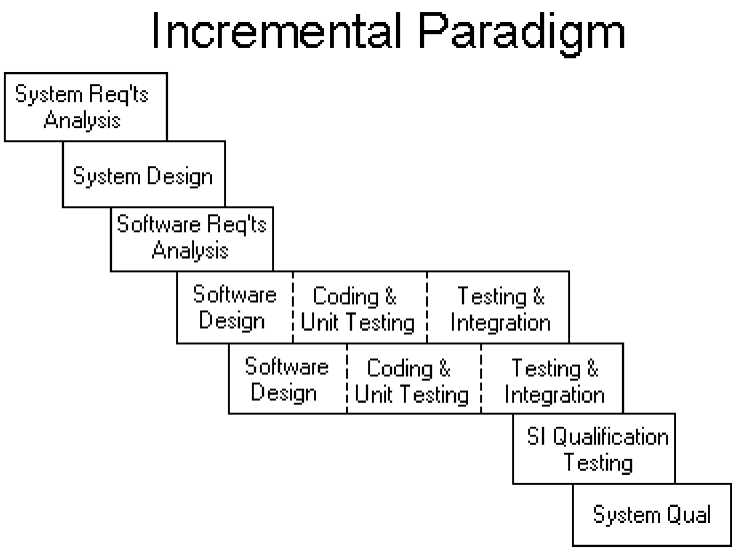
A Precedented System includes the following characteristics:

- Stable system and software requirements, not significantly different than those of previously developed system(s).
- Systems engineering and software development teams with previous experience developing similar systems.

Incremental Paradigm

The Incremental Paradigm involves developing "pieces" of the software for a system in a series of incremental steps. There are many variations of this paradigm. When an incremental approach is used, it is important to make sure that the developer is prepared to build and integrate all of the increments. When using this model, special emphasis should be placed on the selection of the items to be included in the last increment. Sometimes the last increment can be the hardest to complete!

When incremental development is used, an Integrated Product Team (IPT) may be used to help define the number, size, and phasing of the increments. Involving the IPT can reduce risk and ensure that all of the user's requirement will be satisfied by the increments.



Spiral Model

The Spiral Model is a risk-driven prototyping approach to software development. This model:

- Identifies high-risk areas (e.g., user interface, cost, performance constraints, evolving requirements, etc.) and develops software prototypes starting with the highest risk first.
- Allows development to begin before the final design is fully evolved.
- Uses feedback from these prototypes for mitigating risks.

Spiral Model development is especially appropriate for unprecedented software-intensive systems.

Key characteristics of the Spiral Model include:

- Risk based-prototyping.
- Feedback from prototype.
- Elaboration of draft documentation during the life cycle.
- Repetition until risk is at an acceptable level.

Unprecedented System

An Unprecedented System is one that has not been developed before. No models of previous system (s) or experience base exist on which to base the development of a new, similar system.

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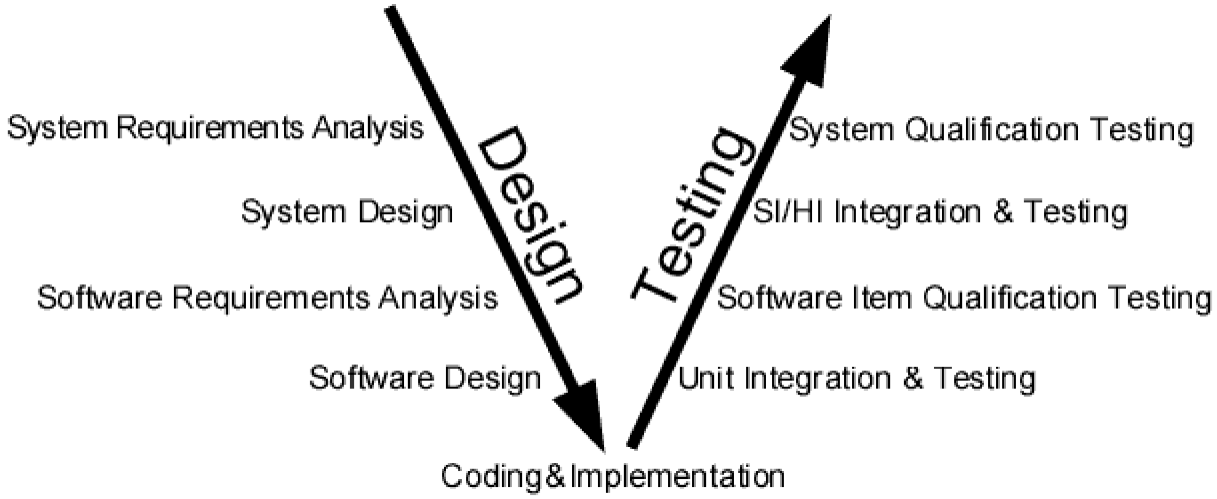
Software Development

This section presents key activities related to software development. The use of a software development paradigm does not negate the need to implement an overall systematic development process within that paradigm.

Overview of Software Development

Typically, software is designed using a "top-down" strategy. After software coding and implementation, testing and integration follow a "bottom-up" strategy. When illustrated, the software development process looks like a V-shape.



System Requirements Analysis and System Design

During these steps, the Systems Engineering Process:

- Develops complete and consistent top-level specifications.
- Determines which requirements are best performed through software.

Software Requirements Analysis

Based on the overall Systems Design, the software developer then:

- Helps to finalize the selection of Software Items (SIs).
- Determines detailed requirements for each SI.

Software Requirements Specification

One key to effective software development is well defined software requirements. The result of the Software Requirements Analysis step is a detailed software requirements specification. Software requirements are typically detailed in a Software Requirements Specification (SRS). This document becomes the "blueprint" for each Software Item to be developed.

Unstable Requirements

Software requirements specifications are important. Well designed and defined requirements can prevent "requirements creep" that can lead to unstable requirements. Unstable and ill-defined requirements are major cost and schedule drivers.

Building Stable Requirements

To ensure stability, requirements should be stated so that they are:

- **Traceable:** Requirements should be able to be tied to system and user requirements.
- **Understandable:** Users and developers should be able to understand the requirements.
- **Achievable:** The developer should be able to achieve the requirements within the estimated

cost.
- **Measurable:** Developers and users should be able to measure the requirements during testing.

Software Design

After the requirements are stabilized, the developer builds detailed designs for each Software Item. At this point it is critical to ensure that all requirements are addressed. Requirements are carefully traced from one development stage to the next.

Coding and Implementation

During this phase the developer writes or implements the code for each Software Unit. Each Software Unit is then tested in a stand-alone mode. Remember, each Software Item can be arranged into several Software Units.

Comprehensive Testing

The focus of the development process now shifts to conducting comprehensive computer-based testing. Comprehensive testing demonstrates that the delivered software will satisfy the requirements. Although not mentioned before, some human-based software testing begins much earlier.

Types of Software Testing

Software testing can be divided into the broad categories of human-based and computer-based testing. The type of testing performed depends on the software development stage.

Human-Based Testing

Human-based testing is a method of examining:

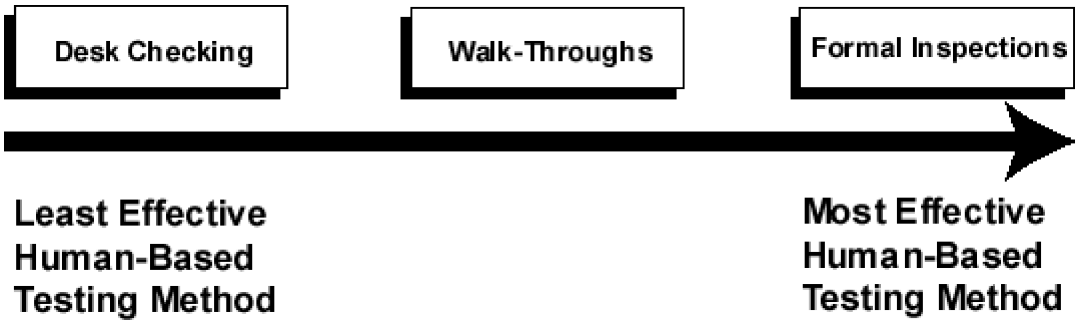
- Requirements
- Design
- Code

This type of testing is primarily a manual process. Testing begins as early as possible in the software development life cycle.

Human-based testing identifies software errors early when those errors are cheapest to correct. This type of testing is critical for ensuring software quality.

Examples of Human-Based Testing

Examples of human-based testing include:



Desk Checking

Desk checking involves individuals reviewing the quality and correctness of their own work. Although commonly used, desk checking is not very effective at uncovering errors.

Walk-Throughs

During a walk-through, the author of the product being evaluated makes a presentation of the product (e.g., software requirements, design, and code) to a group for review.

The presentation is followed by a general discussion from the participants after which the presenter receives feedback on the specific item being reviewed.

Formal Inspections

Formal Inspections (also called Peer Reviews):

- Are led by a trained, impartial moderator.
- Involve inspection teams that use established criteria to review the software product (e.g., software requirements, design, and code).
- Are done primarily by the software developer. However, the Government may participate at requirement-level reviews.
- Are highly effective when done properly.

Computer-Based Testing

Computer-based testing:

- Refers to those testing activites that start after coding is complete.
- May use a variety of Computer-Aided Software Engineering (CASE) tools.

Computer-Based Testing: Examples

Examples of Computer-Based Testing include:

- Software Unit Testing
- Software Unit Integration and Testing
- Software Item Qualification Testing
- Hardware Item and Software Item Integration and Testing
- Subsystem Integration and Testing
- System Qualification Testing

Software Unit Testing

Software Unit Testing is a low-level test of an individual Software Unit. Software units are typically routines, modules, or smaller portions of a larger program.

Software Unit Integration and Testing

Many Software Units make up a Software Item. Unit Integration and Testing involves progressive integration of the units making up an SI and testing their operation with one another, including internal interfaces.

Software Item Qualification Testing

After all the units have been integrated and tested, the Software Item they comprise is tested as an entity. The basis of this test, which can be called "Qualification Testing," is typically described in the Software Requirements Specification (SRS).

Hardware Item and Software Item Integration and Testing

This level of testing involves integration and testing of the various Hardware Items (HIs) and Software Items (SIs) that can make up a subsystem.

Subsystem Integration and Testing

This test involves the integration, testing, and qualification of the various subsystems that make up the complete system being developed.

System Qualification Testing

This type of testing is a high-level technical test designed to qualify the entire system against its systems-level requirements, which are typically described in the System Specification.

Managing Development Risk

Development of some categories of software-intensive systems, especially embedded systems, may be high risk. Some examples of these high risk categories include:

- Real-time critical software systems that generate some action in response to external events under severe time and reliability constraints.
- Programs having a high cost of failure in terms of human life, national security, or mission success.

For these inherently risky systems, the Program Manager may choose to use an appropriate level of Independent Validation and Verification (IV&V).

Independent Verification and Validation

Independent Verification and Validation (IV&V) is the systematic evaluation of software products and activities by an agency that is not responsible for the system development.

Verification involves confirming that either a result is correct or that a procedure or sequence of operations has been performed. An example of Verification is determining that the software requirements analysis is complete and that software design activities can be started.

Validation involves testing to ensure that software requirements are implemented correctly and completely. An example of Validation is acceptance testing, where the system is put through its paces and its performance is validated against the requirements.

Metrics

In order to determine the status of an acquisition, the Program Manager needs to measure the development progress achieved. DOD policy mandates the use of a software measurement program. Proper use of software measurement (also called metrics or indicators) can provide early insight into cost and schedule risks and product quality.

A software metric is any measure that will allow a manager to measure and evaluate the products and/or the processes of a software development project.

Software Metrics Categories

Software metrics can be classified into the following three categories:

- Management
- Quality
- Process

The choice of the particular metrics to use on a given program should be driven by risk. Programs should measure those areas having the greatest risk impact.

Management Metrics

Management metrics are:

- Primarily concerned with indicators that help determine progress against plan.
- Measures selected from indicators that have an impact on the effect, cost, and schedule of the required effort.

Examples of management metrics include:

- Software Size
- Software Personnel Status
- Computer Resource Margins
- Software Requirements Volatility
- Development Progress
- Test Program Status
- Status of Software Problem Reports

Quality Metrics

Quality metrics help assess product quality attributes such as:

- Performance
- Ease of change
- User satisfaction
- Supportability

Examples of quality metrics include:

- Error Density
- Reliability
- Usability
- Complexity
- Portability
- Correctness
- Modularity
- Maintainability

Process Metrics

Process metrics are indicators that deal with the maturity and robustness of the processes involving organizations, tools, techniques, and procedures that are used to develop and deliver software products.

Organizations with a proven track record with processes, tools, techniques, and procedures in place are considered mature.

Following are examples of models that can be used to assess the maturity of an organization's software development process:

- Software Capability Evaluation Models based on the Software Engineering Institute's (SEI's) Software Capability Maturity Model (SW-CMM).
- U.S. Air Force's Software Development Capability Evaluation (SDCE) Model.

Benefits of Software Measurement Programs

When used properly, a software measurement program can:

- Provide Program Managers with information they need to make any needed adjustments to balance cost, schedule, and performance objectives.
- Help ensure the delivery of a quality product that will satisfy users' needs.
- Generate products that may be more easily and economically supported.

Post Deployment Software Support (PDSS)

When a software-intensive system is fielded, it is only the beginning of an on-going process to maintain, update, and support the software. Within the DOD, this on-going process is frequently referred to as "Post Deployment Software Support (PDSS)" or "Post Production Software Support (PPSS)." Software support is also referred to as "Software Maintenance."

Purpose

The purpose of software support is to ensure that, during the operational life of a software-intensive system, the software continues to support its operational mission. In addition, the software must support any subsequent mission modifications.

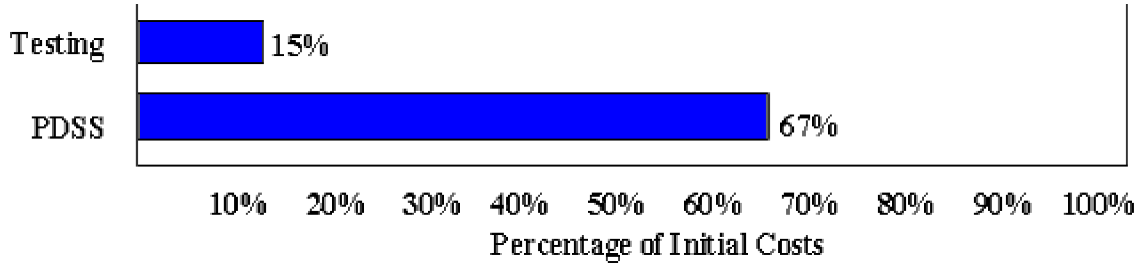
Software Support Activities

The activities for ensuring that fielded software continues to fully support the operational mission of the system include:

- Correcting problems.
- Providing new functions.
- Adapting the product to a modified environment.

Software Life Cycle Cost Percentages

As illustrated below, Requirements Definition, Design, Coding, and Testing make up only 33 percent of the software development life cycle costs. At 67 percent, PDSS is the greatest portion of the software system life cycle costs.



Best Practices

Successful Program Managers have learned the importance of early planning for support and maintenance activities. The following lessons have been captured as "best practices."

- Plan early! Identify anticipated areas of software changes and enhancements.
- Address cost, performance, schedule, and PDSS.
- Establish software support concepts and acquire necessary PDSS resources.
- Address software maintenance concepts for systems that include commercial-off-the-shelf (COTS) products.
- Include PDSS in planning documentation.

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Lesson 24: Production, Quality, and Manufacturing Management

What Is the Fiscal Impact of Production and Manufacturing?

Production and manufacturing account for approximately 30 percent of the life-cycle costs for a system. This amount is three times the resources spent on all the development to this point! A great amount of money is spent during a short time period. When problems occur in manufacturing, they affect the entire acquisition process—at an exponential rate and cost. Problems during this phase are seldom resolved quickly or cheaply.

PM Production Responsibilities

The Program Manager (PM) needs to be especially aware of and avoid activities that can contribute to wasted efforts. Factors such as changing design requirements, late design releases, lack of production planning, and unstable funding can result in increased costs and production delays.

Because of the magnitude of the fiscal impact of production and manufacturing, there is a high degree of service and congressional interest in this process.

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Design Engineering and Production

DOD 5000.2-R states that:

- Producibility shall be a priority of the design effort.
- Manufacturing must be integrated into the design process in order to reduce program risk.
- Design engineering efforts shall focus on concurrent development of producible designs, capable manufacturing processes, and process controls to ensure requirements satisfaction and minimize manufacturing costs.

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The Three-Step Production and Manufacturing Integration Process

Production and manufacturing can best be integrated using a three-step process.

Step 1: Influence the Design Process

Integrate manufacturing considerations into the evolutionary requirements process, acquisition strategy development, system design, and program risk management.

Step 2: Prepare for Production

Deploy the customer's critical requirements all the way down to the manufacturing operations of the

factory floor. Understand the program's strategy and funding.

Step 3: Execute the Manufacturing Plan

Early success in integration results in a smooth transition to production with known risks. The results should be uniform, defect-free products, with consistent performance and at the lowest cost.

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Basic Elements of a Manufacturing Process

Design is transformed into finished product through a process made up of five basic elements: Manpower, Measurement, Method, Machinery, and Material. The 5Ms are used to ensure the system design is capable of being produced into a uniform, defect-free, reproducible product.

Manpower

Manpower is the utilization of people. Welders working on the Seawolf submarine at General Dynamics (Electric Boat Company) required special training and certification. The certification process took 18 months to 2 years. Imagine what would happen to manpower utilization if the contract requirement started to fluctuate!

Measurement

Often overlooked are the systems needed to measure things from the raw material to the testing of the final system. These measurement systems provide for precision and accuracy in the manufacturing process. Examples of measurement include: inspection, gauges, tolerances, or Statistical Process Control (SPC).

Method

Method represents the way that raw materials are formed, shaped, and held together. Often there are many methods to accomplish the forming of a part. Both the materials and design requirements drive the selection of the methods. For example, boring a hole can be done by drilling with a bit, abrasive water jet, or laser beam. The accuracy and precision needed will usually dictate the method.

Machinery

Machinery varies in types, particularly in terms of the volume of production. Robotics and automated machines differ from those requiring a dedicated operator. For example, manufacturing a satellite involves several highly trained personnel and results in the production of one or two units per year. Contrast this output with the automated machinery used to manufacture millions of ball bearings each year.

Material

Material includes all the raw materials that are needed to produce the parts/assemblies for the system and for the production equipment itself. Materials are often dictated by the functional requirements of the system. For example, an airplane that must be capable of going supersonic speeds requires high-temperature-tolerant, lightweight, and high-strength materials.

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Producibility

Producibility is the relative ease of manufacturing an item or system. Producibility is a design accomplishment resulting from a coordinated effort by:

- Systems/design engineering
- Manufacturing/industrial engineering

This coordinated effort creates a functional hardware design that optimizes ease and economy of:

- Fabrication
- Assembly
- Inspection
- Test and acceptance

A producible design does not sacrifice desired function, performance, or quality.

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Five Top-Level Design Goals

The five top-level design goals for a producible product include the following:

Design for Ease of Fabrication

Designs that are complex to form or shape may result in excessive fabrication time. Also, complex designs often cannot be fabricated at consistent quality levels. New processes may enhance the ease of fabrication of products.

Design for Ease of Assembly

Assembly is the number-one driver of labor costs. The use of computer-based design aids may help to assess how easy a subsystem is to assemble. A balancing act exists between easing assembly and fabrication. The complexity of the fabrication may need to be increased in order to reduce the assembly time.

Design for Multiuse

When possible, the design should specify that the same part or assembly process should be used several times, even across product lines. Multiuse permits certain economies of scale and helps support the logistics aspects of the system.

Minimize Number of Parts

In addition to the cost of material and fabrication, every part has an overhead cost. By minimizing the number of parts, the overall cost of the product—including the cost to support the system—is reduced. The minimization of parts applies to both the number of total parts as well as to the number of different parts.

Maximize Number of Common Parts

Another design goal is to optimize the number of common parts. For example, designers should consider items from a qualified parts list. Common parts potentially could be produced by a large number of suppliers. The use of common parts is preferred over more intricate or complex parts. Tailored, complex parts are harder to machine, cast, or otherwise manufacture. The use of common parts also benefits logistic support.

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What Is a Quality Management Process?

A quality management process is the quality system the contractor uses to ensure:

- Customer satisfaction
- Defect-free products
- Continuous improvement

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Contractor Choice of Quality Process

DOD 5000.2-R (Paragraph 4.3.2) states:

"…The PM shall allow contractors the flexibility to define and use their preferred quality management process that meets program objectives. Third-party certification or registration of a supplier's quality system shall not be required…"

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Key Quality Activities

DOD 5000.2-R specifies that whatever system is adopted by the contractor, it shall include the following key quality activities:

- Establish Capable Processes,
- Monitor and Control Critical Product and Process Variations,
- Establish Mechanisms for Feedback of Field Product Performance,
- Implement an Effective Root-Cause Analysis and Corrective Action System, and
- Continuous Process Improvement.

Allowing contractors more control of the quality process should reduce the cost of the system and improve the overall quality of the system.

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Quality Standards and Systems

Industry and Government consider international quality assurance standards such as International Standards Organization (ISO) 9001 or 9002 when defining basic quality systems. Advanced Quality Systems build upon these basic standards by adding additional product or industry-specific requirements along with requiring the implementation of appropriate advanced engineering and manufacturing quality management practices (e.g., Quality Function Deployment (QFD), or Statistical Process Control (SPC).

D1 9000 (Boeing)

Boeing uses the appropriate elements of ISO 9000 along with early identification of key product and process characteristics. The key characteristics form the major area of concentration for monitoring, controlling, and variability reduction.

Six Sigma (Motorola)

Six Sigma is a process for identifying opportunities for improvement of business and product processes. The process includes a sequence of steps that leads to the identification of opportunities for improvement by first baselining the process capability in errors or defects in parts per million (ppm). The goal of Six Sigma for these processes is 3.4 ppm or fewer defects.

AS 9000 (Aerospace Industry)

AS 9000 cites all elements of ISO 9000 and reinforces these standards with additional specificity for the aerospace industry. These additions are based on FAA regulatory requirements and aerospace industry advanced engineering and manufacturing quality practices.

QS 9000 (Automotive Industry)

Similar to AS 9000, the automotive industry quality standard embraces all elements of ISO 9000 and builds on them. This standard is very prescriptive and mandates specific activities during all product/process phases (e.g., early quality planning, Quality Function Deployment (QFD) in the design phase, and use of Statistical Process Control (SPC)).

Quality Function Deployment (QFD)

Quality Function Deployment (QFD) is a systematic process for truly understanding the user's requirements and expectations and documenting the best approach and methods for satisfying those requirements. The QFD process revolves around understanding what the customer really expects and focuses efforts on satisfying those needs through extensive tradeoff analyses. QFD also provides a way of tracking and tracing tradeoffs through various levels, from requirements through design decisions to production and support processes.

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What Is ISO 9000?

Many contractors are adopting and being certified under ISO 9000. ISO 9000 is a series of international quality assurance system standards. The elements comprising ISO 9000 are similar in intent to the now-cancelled MIL-Q-9858A. ISO 9001 has the broadest scope of the ISO 9000 series.

Philosophical Structure of ISO 9001
Quality System Requirements

1. Management responsibility
2. Quality system
3. Contract review
4. Design control
5. Document and data control
6. Purchasing
7. Control of customer-supplied product
8. Production identification and traceability
9. Process control
10. Inspection and testing
11. Control of inspection, measuring, and test equipment
12. Inspection and test status
13. Control of nonconforming product
14. Corrective and preventive action
15. Handling, storage, packaging, preservation, and delivery
16. Control of quality records

17. Internal quality audits
18. Training
19. Servicing
20. Statistical techniques

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How Is Statistical Process Control Used?

Manufacturing personnel use Statistical Process Control (SPC) extensively to prevent nonconforming material.

SPC is a method for assessing if the process is changing and determining if the manufacturing process is predictable.

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What Does SPC Provide Decision Makers?

SPC consists of a set of statistical tools that provide feedback about the abilities and limitations of a process. These tools should be applied to key/critical processes. SPC presents the decision maker with relevant facts and, in many cases, provides an estimate of the probability of making a wrong or right decision.

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What Can Cause Production Problems?

During the production process, various problems may arise that will adversely affect the acquisition process. There are five major causes of these production problems:

- Unstable Rates and Quantities
- Design Instability
- Undue Emphasis on Schedule
- Inadequate Configuration Management System
- Inattention to Environmental Impact

It is important to understand these "warning flags" so that an IPT can be sensitive to the impact of such factors. IPT members should recognize and assess the effect these factors have on cost, schedule, and performance.

Unstable Rates and Quantities

Any time the rate of manufacturing and/or the overall quantity to be manufactured changes, production efficiency can suffer, leading to increased cost. An effective production line is designed to produce at a cost-effective rate and quantity. Increases and decreases to the projected rate and quantity can result in under- (too little) or over- (too much) production capacity. Both situations can result in cost increase to the program.

Design Instability

When the design changes, the 5Ms often change, and the manufacturing planning is reset to zero. This impact is particularly significant during the fabrication of parts. It takes time to redevelop and/or replan for production when the design is changed. Often there is not enough time or money to address the impacts of a design change adequately. Design instability during production may result

from the design effort not being completed or from changes in the user requirements.

Undue Emphasis on Schedule

Holding firm to a contractual schedule or an initial operational capability (IOC) date when there is excessively high or unknown manufacturing risk is asking for trouble. In the past, customers (combat commanders) wanted their systems so badly that they let time be the sole driver. This emphasis produced poor-quality systems.

Sometimes there is no chance of making schedule because the development of the production processes required some technological breakthrough. Schedule delays are common when the manufacturing solutions require new materials, methods, machines, manpower, and measurement systems. The process needs to be event driven with entry/exit criteria, and not driven solely by schedule or the IOC.

Inadequate Configuration Management System

A corollary to design instability is not knowing which design to produce. Inadequate configuration management can be as devastating as design changes themselves. If the wrong design is executed in manufacturing, it just creates more work trying to correct the problem. Good configuration management goes hand-in-hand with good design control.

Inattention to Environmental Impact

Given the environmental laws and their continued complexity, programs could be faced with both prime contractors and suppliers being shut down or having heavy fines levied for violating environmental laws. In some States, stringent environmental policies are causing companies to move out of the State or shut down all together. Throughout the acquisition process, program management needs to be aware of the changing environmental laws. Where possible, take design and process actions to eliminate environmental hazards.

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